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Calicioid lichens and fungi in the forests and woodlands of western Oregon

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This study examines the diversity and ecology of calicioid lichens and fungi in western North America, with emphasis on the humid forests and woodlands of western Oregon. The study is based on 2103 species observations from 96 survey sites, most of which were located in mature and old-growth forests along a complex environmental gradient over the Cascade Range. This material demonstrates that calicioid lichens and fungi are a diverse component in the mycoflora of western North America. The distribution and frequency status of 82 species are documented, including those of several undescribed taxa. Most species have wide circumpolar or antitropical distributions, but there are also a number of endemics, mainly on conifer resin and bark. The diversity of resinicolous calicioids in the Pacific Northwest is higher than in any comparable region of the world. This is related to the tree species composition and history of the local forests. Most of the endemic species have a coastal distribution and they probably survived Pleistocene glaciations close to their present distribution area. Calicioid communities differ between major forest zones. Site level species diversity is promoted by heterogeneity in forest structure, especially by the increasing availability of aged trees and snags, but also hardwood twigs. Mean site level species richness is highest in the foothills of interior valleys and lowest in dry forests east of the Sierra-Cascade Crest. Some calicioid species in the deciduous woodlands and mixed forests of the Willamette Valley are rare and locally threatened. In humid coniferous forests site level species richness tends to decrease at both ends of the elevational gradient. The macroclimatic optima of many circumpolar calicioids are in relatively continental regions. These species are frequent in interior valleys and at higher elevations, but rare in humid coastal forests. The relative scarcity of calicioids in low-elevation rainforests is conspicuous and caused by a combination of several environmental factors, including adverse microclimate, lack of suitable substrates, bryophyte competition and disturbance by mollusks.

Key words: calicioids, lichens, old-growth forests, snags, vegetation zones

Introduction

Calicioid lichens and fungi constitute a diverse phenotypical grouping of ascomycetes with tiny, usually well-stalked apothecia. Both lichenized and non-lichenized species are involved and the later group includes both parasitic and saprophytic forms (Tibell 1984, 1999, Wedin & Tibell 1997, Wedin *et al*. 1998, Tibell & Wedin 2000, Wedin *et al*. 2000). The mature ascospores of calicioid lichens accumulate on the upper surface of apothecia, forming extensive mazaedia. As the spores are usually dark, the mazaedia tend to stain a finger when touched.

Calicioid lichens and fungi are mainly found in a limited number of restricted, unrelated habitat types, ranging from conifer bark to thin hardwood twigs. The non-lichenized species tend to be highly substrate specific and also many calicioid lichens have specialized habitat requirements. On the other hand, many species are widely distributed and thus calicioid communities are rather uniform over large areas. For example, calicioid-rich epiphyte communities are quite similar in composition over the whole circumpolar belt of boreal coniferous forests and adjoining areas of mixed coniferous-deciduous forest. High species diversity is often found on the basal trunks of damaged, old trees, especially in humid, semi-open forests (Tibell 1975, 1999, Rikkinen 1995).

Several species of calicioid lichens and fungi are most frequent in old-growth forests and some of them have been used as biological indicators of forest antiquity (Hyvärinen *et al*. 1992, Tibell 1992, Selva 1994, U.S.D.A. & U.S.D.I. 1994, Holien 1996, Dettki *et al*. 1998, Kuusinen & Siitonen 1998). The reasons for this old-growth dependency are not uniform nor fully understood, but both substrate availability and microclimate are clearly important in controlling species distributions (Barkman 1958, Rikkinen 1995, Kruys & Jonsson 1997, Rydberg 1997, Kruys *et al*. 1999, Skarp 1999, Peterson 2000a). Due to the effects of habitat destruction, some calicioid species have become rare over large proportions of their range.

Western North America supports a wide variety of forest types reflecting the great diversity in local topography, climate and soil conditions. The climate is mainly controlled by a series of roughly parallel mountain ranges aligned perpendicular to the prevailing flow of moist air from the Pacific Ocean. In the Pacific Northwest this causes a steep transition from hypermaritime to rather continental conditions from west to east. Furthermore, the conditions on windward slopes are more humid than on leeward slopes, and this effect tends to increase towards the south. The forests of western Oregon and Washington range from temperate coniferous rainforests at low elevations near the Pacific Coast, with mixed forests and broadleaf woodlands in interior valleys east of the Coast Range, through montane and subalpine coniferous forests at high elevations in the Cascades, to dry coniferous forests and woodlands at lower elevations east of the Cascade Crest (Franklin & Dyrness 1988). The Klamath-Siskiyou region of SW Oregon and NW California supports coniferous forests and mixed evergreen forests with distinctive, sparse vegetation types on serpentine soils. The montane forests of this region represent northern extensions of montane forests in the Sierra Nevada. The climate in the Sierra Nevada is relatively warm and dry, and a steep inland gradient over the mountains supports a wide variety of coniferous forests and woodlands (Barbour & Major 1977).

Montane forests in western North America, on the whole, still have a comparatively large volume of old forest structure and a high diversity of lichens. However, the calicioid flora of this region has attracted surprisingly little attention. In Washington, Oregon and California the works include some unpublished species inventories (Ponzetti 1996, Rambo *et al*. 1998), reports of range extensions (Otto 1970, 1972, 1983, Pike 1972, Tibell 1978, 1981, McCune & Rosentreter 1992, 1995, Rikkinen 1998, Peterson & Rikkinen 1999), descriptions of new species (Bonar 1971, Redhead 1984, Tibell 1991a, Peterson & Rikkinen 1998, Rikkinen 1999, 2003a, 2003b, Selva & Tibell 1999), and reviews of isolated genera (Weber 1969, Tibell 1976). Similar studies have also been conducted in British Columbia (Tibell 1975, Noble 1982, Goward 1999). Recently, Eric Peterson (2000a) studied the community ecology of calicioids at low elevation forests in the Western Cascades of

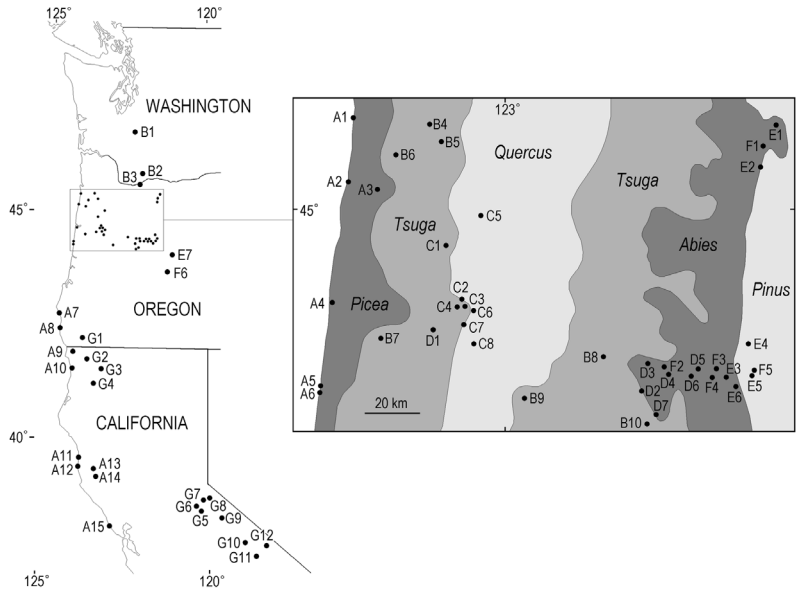

Fig. 1. Collecting sites and generalized vegetation map of main study area in western Oregon. *Picea*, *Picea sitchensis* Zone; *Tsuga*, *Tsuga heterophylla* Zone; *Quercus*, forests and grasslands of the Willamette Valley; *Abies*, montane and alpine vegetation of the Cascades; *Pinus*, dry forests and steppes east of the Cascade Crest (based on Franklin & Dyrness 1988).

Oregon (*Tsuga heterophylla* Zone), comparing old-growth and young stands, and modeling species occurrence over the landscape.

The purpose of this study is to offer a preliminary analysis of the diversity, ecology, distribution and frequency status of crustose calicioids in the forests and woodlands of western North America, with emphasis on the humid conifer forests of western Oregon. A detailed analysis of substrate relationships is beyond the scope of this treatment and will be returned to in a future paper. The investigation is based on specimens collected by the author in the Pacific Northwest and central California in 1992, 1996 and 1997–1998.

Material and methods

Study area

In total, 96 localities were surveyed for site-level species inventories, with a primary goal to maximize species capture in the limited amount of time allotted (0.5–6 h per site). Most of the localities were in mature and old-growth forests along a complex environmental gradient over the Cascade Range in western Oregon (Fig. 1). The collecting localities are briefly described below. They have been organized into seven main groups (A–G) corresponding to major forest zones or zone complexes, the delimitation of which essentially follows those of Franklin and Dyrness (1988), and Barbour and Major (1977).

A: Coastal forests. — Temperate coniferous forests extending as a narrow zone from Alaska to central California. The zone of coastal forests is often only a few kilometers wide and in central Oregon its elevational range extends from sea level to 100–600 m. The climate is hypermaritime and wet. The annual precipitation averages 2000 to 3000 millimeters, with frequent fogs giving additional moisture during the relatively drier summer months.

***Picea sitchensis* Zone**. — *Picea sitchensis* characterizes coastal forests in Oregon, although in many places *Pseudotsuga menziesii* and *Tsuga heterophylla* dominate (Fig. 2). *Alnus rubra* characterizes riparian areas and *Thuja plicata* is common in swampy habitats (Fig. 3). *Pinus contorta* dominates stabilized dune communities.

OREGON. **1**: Tillamook Co.: Cape Lookout State Park, along trail to Cape, old-growth *P. sitchensis–Ts. heterophylla* forest with dense understory of *Rubus spectabilis, Gaultheria shallon* and other shrubs (45°20.58´N, 123°59.24´W, elev. 90 m). **2a–c**: Tillamook Co.: Cascade Head. **2a**: Upper Cascade Head Conservance Trail, mature *Alnus rubra* stand with scattered young *P. sitchensis* (45°03´N, 124°00´W, elev. 365 m). **2b**: Along Forestry Road 1861, Mature *P. sitchensis* stand

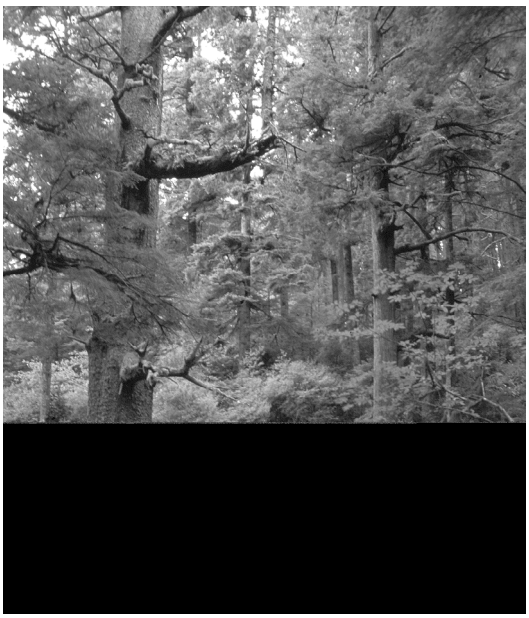

Fig. 2. Coastal forest with old-growth *Picea sitchensis* (Cape Perpetua, OR, near survey site A5).

Fig. 3. Stands of *Alnus rubra* characterize many riparian habitats in the *Picea sitchensis* and *Tsuga heterophylla* Zones (Cape Perpetua, OR, near survey site A5).

with abundant coarse woody debris (45°03.2´N, 123°54.3´W, elev. 215 m). **2c**: Hart's Cove Trail, old-growth *P. sitchensis* forest (45°04.3´N, 124°00.3´W, elev. 120 m). **2d**: Neskowin Trail, old-growth *P. sitchensis* forest (45°04.3´N, 124°00.3´W, elev. 50 m). **3a**–**b**: H. B. Van Duzer Forest Corridor Wayside. **3a**: Lincoln Co.: East bank of Salmon River, mature riparian forest with *Ts. heterophylla, Ps. menziesii, A. macrophyllum, A. rubra,* and remnant *P. sitchensis* (45°02.25´N, 123°48.63´W, elev. ca. 150 m). **3b**: Tillamook Co.: Mature swampy forest with *Ts. heterophylla, Ps. menziesii, T. plicata,* and remnant *P. sitchensis* (45°03.1´N, 123°46.7´W, elev. ca. 180 m). **4**. Lincoln Co.: Mike Miller Educational Forest, old-growth *P. sitchensis–Ts. heterophylla* forest, with dense understory of *G. shallon* and other shrubs; also *Ps. menziesii, P. contorta, A. rubra,* and *Rhododendron macrophyllum* (44°36.3´N, 124°03.2´W, elev. 30 m). **5a**–**b**. Lane Co.: Cummins Creek Wilderness, Gwynn Creek (44°16´N, 124°06´W). **5a**: Mature conifer forest with remnant old-growth *P. sitchensis* and younger *Ts. heterophylla* (elev. 40–80 m). **5b**: Outlet of Gwynn Creek, edge of young *P. sitchensis* forest (elev. 15 m). **6a**–**b**: Lane Co.: Cummins Creek Wilderness, Cummins Creek (44°16´N, 124°06´W). **6a**: Mature conifer forest with old-growth *P. sitchensis* and younger *Ts. heterophylla* (elev. 80–120 m). **6b**: Riparian *A. rubra–Polystichum munitum* forest with *A. macrophyllum, T. plicata* and remnant old-growth *P. sitchensis* (elev. 40–70 m). **7a**–**b**: Curry Co.: Humbug Mountain State Park, along summit trail. **7a**: Mixed forest of *Lithocarpus densiflorus, Quercus chrysolepis, A. macrophyllum*, and *A. rubra*, with isolated mature *Ps. menziesii* (42°41.1´N, 124°26.1´W, elev. 50–100 m). **7b**: Young *Ps. menziesii* forest with remnant *Ps. menziesii* and *Ts. heterophylla* (42°40.9´N, 124°26.4´W, elev. 120–500 m). **8**. Curry Co.: Cape Sebastian. Deep gully between Cape Sebastian State Park and Buena Vista Ocean Wayside, mature conifer forest with *Ps. menziesii* and *Ts. heterophylla* on upper slopes and old-growth *P. sitchensis* near bottom of gully (42°20.3´N, 124°25.1´W, elev. 70–120 m).

Redwood forests. — In northern California the zonation of coastal forests is rather complex and follows both latitudinal and inland gradients. *Sequoia sempervirens* characterizes the forests, but also *Picea sitchensis*, *Pseudotsuga menziesii*, *Abies grandis*, and *Tsuga heterophylla* are important (Fig. 4). *Alnus rubra* characterizes riparian sites. The zone of redwood forests is usually less than 20 km wide and not always at the immediate coast. *Arbutus menziesii* and oaks increase towards the east, while *Pinus muricata* and other coastal pines increase towards the south.

CALIFORNIA. **9**: Del Norte Co.: Jedediah Smith Redwoods State Park, old-growth *S. sempervirens* forest (41°48.6´N, 124°05.9´W, elev. ca. 200 m). **10a**–**b**: Del Norte Co.: Redwood National Park. **10a**: Lost Man Creek, old-growth *S. sempervirens* forest (41°19.5´N, 124°00.7´W, elev. 100 m). **10b**: Along trail from Elk Prairie to Fern Gully, old-growth *S. sempervirens* forest; also *P. sitchensis*, *Ts. heterophylla*, *A. macrophyllum,* and *A. rubra* (41°22.69´N, 126°01.88´W, elev. 60 m). **11**: Mendocino Co.: Russian Gulch Creek, moist mixed forest with *Ts. heterophylla*, *Ps. menziesii*, and *A. rubra* (39°20´N, 123°47´W, elev. 40 m). **12**: Mendocino Co.: Pygmy cypress forest with *Cupressus pygmea*, *P. contorta,* and *P. muricata* (39°16´N, 123°45´W, elev. 150 m). **13a**–**b**: Mendocino Co.: Jackson State Forest.

Fig. 4. Old-growth *Sequoia sempervirens* forest (Hendy Woods State Park, CA, survey site A14).

13a: Along Orr Springs Road. Open *Quercus garrayana* woodland (39°11.5´N, 123°16´W, elev. 500 m). **13b**: Montgomery Woods State Park. Mixed conifer forest with *Ps. menziesii* and *S. sempervirens* (39°13´N, 123°23´W, elev. 250 m). **14**. Mendocino Co.: Hendy Woods State Park, old-growth *S. sempervirens* forest (39°05´N, 123°23´W, elev. 200 m). **15**. Marin Co.: Point Reyers National Seashore, along Estero trail to Home Bay (38°04´N, 122°55´W, elev. 10 m).

B: *Tsuga heterophylla* Zone. — Temperate coniferous forests extending from British Columbia to northern California and mantling the Coast Range and lower western slopes of the Cascades Range. Elevational range in Oregon is from 150 to 1000 m. The climate is mild and moist, with greater moisture and temperature extremes than in the *Picea sitchensis* Zone. Annual precipitation averages 1500 to 3000 millimeters and occurs mainly during the winter. Although named for the potential climax species *Tsuga heterophylla*, the forests are often dominated by the seral *Pseudotsuga menziesii*. *Alnus rubra*, *Acer macrophyllum*, and *Thuja plicata* characterize riparian and swampy sites (Fig. 5). *Abies amabilis* is important at higher elevations, and in the south also *Pinus ponderosa* and *Calocedrus decurrens* occur in this zone.

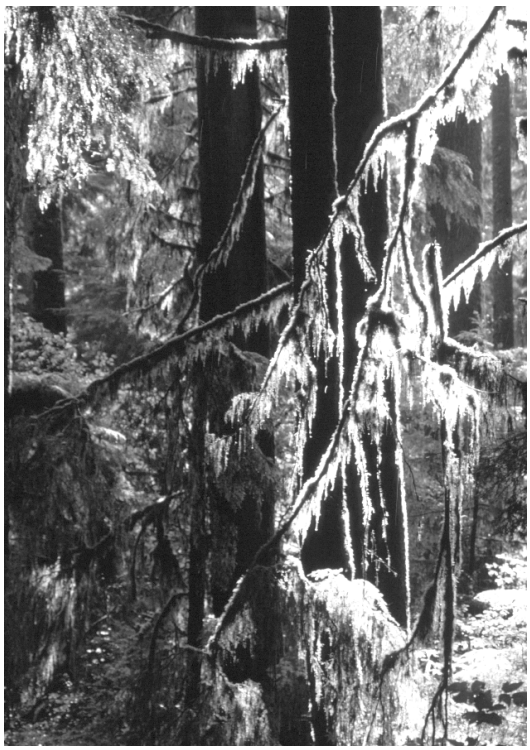

Fig. 5. Wet coniferous forest in the *Tsuga heterophylla* Zone (Wind River Experimental Forest, WA, survey site B2).

WASHINGTON. **1**: Thurston Co.: Bald Hill Natural Area, old-growth forest, overstory dominated by *Ps. menziesii*, with occasional *T. plicata* and *A. macrophyllum*, and younger *Ts. heterophylla* (46°49´N, 122°26´W, elev. ca. 200 m). **2a–c**: Skamania Co.: Wind River. **2a**: Wind River Experimental Forest, riparian old-growth forest with *Ps. menziesii, Ts. heterophylla, T. plicata, T. brevifolia*, and *A. rubra* (44°48.5´N, 121°57.2´W, elev. 320 m). **2b–c**: Thorton T. Munger Research Natural Area. **2b**: Whistle Punk Trail. Seasonally flooded *Fraxinus latifolia* swamp; also *Ts. heterophylla* and *A. rubra* (45°49´N, 121°58´W, elev. ca. 350 m). **2c**: Wind River Canopy Crane Research Facility, dense old-growth forest, with *Ts. heterophylla* (lower and middle canopy), *Ps. menziesii* (upper canopy), and *A. amabilis* (45°49.14´N, 121°57.07´W, elev. 355 m). OREGON. **3a–c**: Multnomah Co.: Columbia Gorge. **3a**: Latourell Creek, thallus slope west of Crown Point bridge (45°35.4´N, 122°04.6´W, elev. 140 m). **3b**: Oneota Gorge. Basal section of high seepage-moist cliff (elev. 60 m). **3c**: Ainsworth State Park, semi-open hardwood forest on steep thallus slope, with many trees damaged by falling rock, avalanches and landslides (45°35.42´N, 122°03.58´W, elev. 260 m). **4a–b**: Tillamook Co.: Nestucca River Area of Critical Environmental Concern (45°19.0´N, 123°27.8´W). **4a**: Old-growth conifer forest on steep slope, overstory dominated by *Ps. menziesii*, with subcanopies of *T. plicata* and *Ts. heterophylla* (elev. 460–500 m). **4b**: Herb-rich riparian *A. rubra* stand with isolated *T. plicata* (elev. 460 m). **5**: Tillamook Co.: Sheridan

Fig. 6. Deciduous forests and woodlands in the Willamette Valley support a rich epiphytic lichen flora (Corvallis, Or, near survey site C6).

Peak Research Natural Area, mature *Ps. menziesii* forest with large remnant snags; also younger *Ts. heterophylla* and stands of *A. rubra* (45°17´N, 123°28´W, elev. 750–850 m). **6**: Tillamook Co.: Little Nestucca River, mature *A. rubra* stand with occasional mature *Ps. menziesii* and younger *Ts. heterophylla* (45°07.6´N, 123°50.1´W, elev. 170–250 m). **7**: Lincoln Co.: Flynn Creek Research Natural Area, mature *Ps. menziesii* forest with younger *Ts. heterophylla* and *T. plicata*, interspersed with stands of *A. rubra* (44°32.3´N, 123°51.2´W, elev. 170–250 m). **8**: Linn Co.: Cascadia State Park, mature conifer forest with *Ps. menziesii*, *Ts. heterophylla*, *T. plicata*, and *A. macrophyllum* (44°23.9´N, 122°28.3´W, elev. 365 m). **9a–b**: Linn Co.: Horse Rock Ridge Research Natural Area (44°18´N, 122°52´W). **9a**: Open rocky ridgetop and adjoining forest of *Ps. menziesii* and *Castanopsis chrysophylla*, with patches of shrub-like *Q. garrayana* and large *Arctostaphylos columbiana* (elev. 760 m). **9b**: Dense old-growth forest on steep slope, with *Ts. heterophylla, T. plicata*, and *Ps. menziesii*. (elev. 740 m). **10a–b**: Lane Co.: H. J. Andrews Experimental Forest. **10a**: Lookout Creek, dense old-growth forest, with *Ps. menziesii*, *Ts. heterophylla,* and *T. plicata* (44°13.9´N, 122°13.2´W, elev. 535 m). **10b**: Mack Creek, dense old-growth forest, with *Ps. menziesii*, *Ts. heterophylla,* and *T. plicata* (44°12.8´N, 122°09.2´W, elev. 925 m).

C: Willamette Valley forest-grassland complex. — Temperate forests, woodlands, and grasslands occupying the bottomland and adjoining slopes of the Willamette Valley (Fig. 6). Enclosed by the Coast Range to the west and the Cascade Range to the east. Elevational range is from 60 to 300 m. A relatively warm and dry region in the rain shadow of the Coast Range. Summers are warm and dry, winters mild and wet. Annual precipitation averages 800 to 1200 millimeters. Most forests and woodlands in the Willamette Valley are under extensive human influence.

Foothill forests. — Temperate coniferous forests and mixed forests on the foothills of the Willamette Valley. Temperatures are somewhat lower and precipitation is higher than in the bottomland forests. *Pseudotsuga menziesii* is dominant, but *Abies grandis* and *Acer macrophyllum* also are common. *Tsuga heterophylla* only occurs in the peripheries of the region where the foothill forests grade into the *Tsuga heterophylla* Zone.

OREGON. **1**: Polk Co.: Little Sinks Research Natural Area, Semi-open riparian forest around beaver ponds with mature *Ps. menziesii, A. grandis, A. marcophyllum*, and *A. rubra* (44°50.29´N, 123°26.39´W, elev. 200 m). **2**: Benton Co.: McDonald Research Forest, between Cronemiller Lake and Powder House, mature conifer forest, with remnant *Ps. menziesii* and younger *A. grandis*. Also *T. brevifolia, A. macrophyllum*, and *A. rubra* (44°39.9´N, 123°14.6´W, elev. 180–200 m). **3**: Benton Co.: McDonald Research Forest, Sulphur Springs, mature herb-rich forest around beaver pond in moist stream gully, with *Ps. menziesii, A. grandis, A. macrophyllum, T. brevifolia*, and *A. rubra* (44°38.47´N, 123°18.79´W, elev. 180–185 m). **4**: Benton Co.: McDonald Research Forest, Oak Creek, herb-rich riparian forest with *A. rubra*, *A. macrophyllum*, *F. latifolia*, *Ps. menziesii*, and *A. grandis* (44°36.2´N, 123°20.1´W, elev. ca. 150 m).

Bottomland forests and woodlands. — Temperate forests and woodlands on the bottom of the Willamette Valley. Open woodlands are dominated by *Quercus garrayana*, with *Toxicodendron diversiloba* and grasses in the understory. *Acer macrophyllum* is prominent on mesic sites, while *Fraxinus latifolia* and *Populus trichocarpa* characterize riparian forests. Many broadleaf forests and woodlands are being invaded by *Pseudotsuga menziesii* and *Abies grandis*.

OREGON. **5**: Polk Co.: Baskett Slough National Wildlife Refuge, along Mount Baldy loop trail. *Q. garrayana* forest (44°58.1´N, 123°15.5´W, elev. 120 m). **6**: Benton Co.: Chip Ross Park, mixed semi-open forest with *Q. garrayana, A. macrophyllum*, and *Ps. menziesii*. Understory of *T. diversiloba,* other scrubs and grasses (44°36.4´N, 123°16.9´W, elev. 175–250 m). **7a–b**: Benton Co.: Corvallis. **7a**: Willamette Park, riparian forest with *A. macrophyllum, P. trichocarpa, F. latifolia*, and many shrubs (44°32.4´N, 123°14.9´W, elev. 65 m). **7b**: Walnut Park, hardwood thicket with young *Q. garrayana*, *Rhamnus purshiana*, *Crataegus douglasii*, and *T. diversiloba* (44°34´N, 123°17´W, elev. 120 m). **8a–b**: Benton Co.: William L. Finley National Wildlife Refuge. **8a**: Mill Hill Loop, mixed forest with *Q. garrayana, A. macrophyl-*

lum, C. cornuta, Ps. menziesii, and *A. grandis*, dense understory of deciduous shrubs (44°24´N, 123°20.9´W, elev. 130 m). **8b**: Woodpecker Loop, mature herb-rich forest with *Q. garrayana, A. macrophyllum, F. latifolia, C. cornuta,* and *R. diversiloba* (44°35´N, 123°20.1´W, elev. 100 m).

D: Montane forests west of the Cascade Crest. — Upper orotemperate and oroboreal coniferous forests on the western slopes of the Cascade Range extending from British Columbia to central Oregon (*Abies amabilis* Zone). Similar forests also are found on high peaks of the northern Oregon Coast Ranges. Elevational range in Oregon is from 900 to 1500 m. The climate is relatively mild and wet, with a large proportion of precipitation falling as snow. Annual precipitation averages 2000 to 3000 millimeters. Forest composition varies depending on stand age and locale (Fig. 7). Typical tree species include *Abies amabilis*, *Abies procera*, *Pseudotsuga menziesii*, and *Tsuga heterophylla*. The major climax species is *A. amabilis*. Areas of volcanic ash support stands of *Pinus contorta*. Dense thickets of *Alnus sinuata* characterize sites with heavy snow accumulations or abundant seepage water. Hardwoods are uncommon, but many riparian forests have dense shrub layers. Lush herbaceous understories characterize mesic and hygric sites.

OREGON. **1**: Benton Co.: Mary's Peak, along summit trail from Parker Creek Campground, old-growth *Abies procera* forest (44°30.4´N, 123°33.3´W, elev. 1050–1150 m). **2**: Linn Co.: Squaw Mountain. Mature *Ps. menziesii–Abies* forest (44°20.1´N, 122°09.90´W, elev. 1470 m). **3**: Linn Co.: Iron Mountain. Mature *Ps. menziesii–Abies* forest (44°23.9´N, 122°08.08´W, elev. 1300–1500 m). **4**: Linn Co.: Hackleman Grove, old-growth *Ps. menziesii–Ts. heterophylla–Abies* forest (44°23.89´N, 122°05.60´W, elev. 1100 m). **5**: Linn Co.: Near Santiam Junction, old-growth *Ps. menziesii* forest (44°25´N, 122°00´W, elev. 1000 m). **6a–c**: Linn Co. Near Santiam Junction (44°26.3´N, 121°59.9´W). **6a**: Mature *P. contorta* stand with remnant *Ps. menziesii* (elev. 1150 m). **6b**: Old-growth *Ps. menziesii* dominated forest with occasional *P. contorta* and *P. ponderosa* (elev. 1200 m). **6c**: Lost Lake. Mature *P. trichocarpa* stand by lake shore (elev. 1200 m). **7**: Lane Co.: H. J. Andrews Experimental Forest, Lookout Ridge. Mature *Ps. menziesii-Abies* forest on steep slope (44°13.1´N, 122°06.1´W, elev. 1495 m).

E: Montane forests and woodlands east of the Cascade Crest. — Temperate and oroboreal forests on the eastern slopes of the Cascade Range.

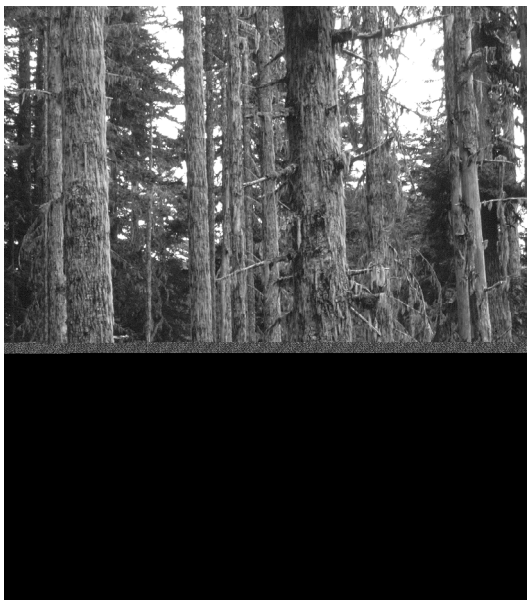

Fig. 7. Forest structure in the *Abies amabilis* Zone varies depending upon stand age, history and local conditions (Iron Mountain, OR, survey site D3).

A complex array of forest formations characterized by *Pinus ponderosa* (*Abies grandis* and *Pinus ponderosa* Zones). Also open woodlands typified by *Juniperus occidentalis*, mixing with shrub-steppe communities at the lower timberline (*Juniperus occidentalis* Zone). Many midslope positions east of the Cascade Crest support mixed coniferous forests with many tree species, particularly in seral stands (Fig. 8). The elevational range in Oregon is from 1100 to 1500 m. The climate is relatively mild and moist with most of the precipitation falling as snow. Annual precipitation averages 600 to 1500 millimeters. Major tree species include *Abies grandis*, *Pseudotsuga menziesii*, *Pinus contorta, P. ponderosa*, and *Larix occidentalis*. *Pinus ponderosa* forests occupy a narrow band on the eastern flanks of the Cascade Range as well as large areas in the interior mountains. Elevational range in central Oregon is about 900 to 1500 m, depending on locale. The climate is characterized by a short growing season and minimal summer rains. Annual precipitation averages 350 to 750 millimeters, and much of it falls as snow. Mature *P. ponderosa* stands are typically quite open, with few other tree species, except *J. occidentalis* in xeric localities and *Populus tremuloides* in

Fig. 8. Riparian forests bordering ancient lava flows provide an ideal habitat for many calicioid lichens and fungi (Newberry Crater, OR, survey site F6).

Fig. 9. Ancient *Juniperus occidentalis* snag (Horse Ridge Research Natural Area, OR, survey site E7). Some junipers at this site are over 1000 years old.

riparian stands. *Abies grandis*, *Ps. menziesii*, *L. occidentalis, P. contorta*, and *Pinus monticola* are common associates in seral stands. *Juniperus occidentalis* woodlands represent the most xeric tree-dominated formation in the Pacific Northwest. Summers are hot and dry. Annual precipitation averages 200 to 350 millimeters with almost all rain falling during the winter months. *Juniperus occidentalis* is typically the only tree species present along with a sparse undergrowth of *Artemisia tridentata*, various grasses, and herbs (Fig. 9).

OREGON. **1**: Hood River Co.: Robinhood Campground, mature mixed conifer forest along river bank (45°20.4´N, 121°34.3´W, elev. ca. 1050 m). **2**: Wasco Co.: Clear Lake, semi-open mature mixed conifer forest with abundant windthrow (45°11.2´N, 121°41.7´W, elev. ca. 1150 m). **3a–b**: Elliot R. Corbett II Memorial State Park. **3a**: Deschutes Co.: Between Cub Lake and Cache Mountain, semi-open mature forest with *A. grandis, A. amabilis, A. lasiocarpa, Tsuga mertensiana, Ps. menziesii*, and *Picea engelmannii* (44°23.14´N, 121°47.93´W, elev. ca. 1300 m). **3b**: Jefferson Co.: Island Lake, mature conifer forest with *Abies, Ps. menziesii*, *P. monticola*, and *P. engelmannii*. *Populus* and *Alnus* near lake shore (44°24.32´N, 121°48.30´W, elev. ca. 1200 m). **4**: Jefferson Co.: Between Candle Creek and Parker/Jefferson Creek, fragment of aged riparian *P. ponderosa–Ps. menziesii–L. occidentalis–Abies* forest by an ancient lava flow with scattered conifers and deciduous shrubs (44°34.46´N, 121°39.67´W, elev. ca. 900 m). **5**: Jefferson Co.: Black Butte, lower part of trail from NFD 1110, semi-open *P. ponderosa–A. grandis* forest on slight to moderate slope (44°24.07´N, 121°38.81´W, elev. ca. 1680 m). **6**: Deschutes Co.: Windy Point, semi-open mixed conifer forest along ancient lava flow, with *Abies* sp., *P. ponderosa, P. contorta, Ps. menziesii*, and *Salix* sp. (44°17.5´N, 121°45.8´W, elev. 1460 m). **7**: Deschutes Co.: Horse Ridge, semi-open *J. occidentalis–A. tridentata* woodland (43°56.35´N, 121°03.69´W, elev. ca. 1250 m).

F: Subalpine forests. — Oroboreal forests along the crest of the Cascade Range and on high elevations east of the Crest (*Tsuga mertensiana* and *Abies lasiocarpa* Zones). Lower elevational boundary is usually 1500 m or more. The climate is cool and wet. Annual precipitation averages 1500 to 3000 millimeters. Cool summers, cold winters, and thick winter snow-packs are characteristic. Forest composition varies widely depending on locale. The major climax species is *Tsuga mertensiana*, with *Abies lasiocarpa*, *Abies amabilis*, and *Pinus contorta* being important associates. In more continental areas, *A. lasiocarpa* is the major climax species (Fig. 10). *Chamaecyparis nootkatensis*, *Pinus monticola*, and *Picea engelmannii* also occur in this zone. At high elevations, the continuous forest breaks into a mosaic of forest patches interspersed with shrubby or herbaceous meadows.

OREGON. **1**: Hood River Co.: Bennett Pass, semi-open mature forest with coniferous forest, with *Abies* sp., *P. con-*

Fig. 10. *Abies lasiocarpa* forest near timberline (summit of Black Butte, OR, survey site F5).

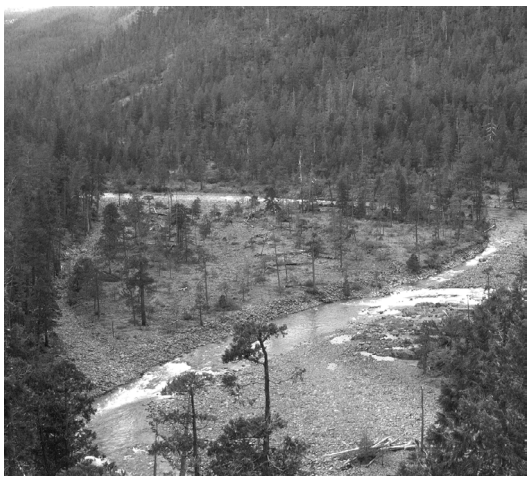

Fig. 11. Riparian forest on serpentine soil (Rough and Ready Creek, OR, survey site G1).

torta, and *Ts. mertensiana* (45°18.7´N, 121°38.6´W, elev. 1300 m). **2**: Linn Co.: Echo Basin, old-growth *A. amabilis–Ts. mertensiana* forest; also *A. procera* and *C. nootkatensis* (44°24.83´N, 122°05.64´W, elev. 1400 m). **3**: Jefferson Co.: Santiam Pass, along trail to Square Lake, mixed coniferous forest with *Abies* sp., *P. contorta, Ts. mertensiana*, and dead *P. engelmanii* (44°25.7´N, 121°50.5´W, elev. 1500 m). **4**: Jefferson Co.: Hayrick Butte. Dense *Abies–Ts. mertensiana* forest on steep mountain slope (44°24.29´N, 121°51.94´W, elev. 1550 m). **5a–b**: Jefferson Co.: Black Butte (44°24.00´N, 121°38.50´W). **5a**: Upper section of summit trail, open *Pinus albicaulis* stand on moderate slope, with dense understory of shrubs (elev. ca. 1750 m). **5b**: Open *Abies lasiocarpa* forest with low stunted trees (elev. 1960 m). **6a–c**: Deschutes Co.: Newberry Crater. **6a**: Between East Lake and The Dome, mature *Ts. mertensiana* forest (43°62.85´N, 121°11.09´W, elev. ca. 2150 m). **6b**: Paulina Lake, mature conifer forest, with *Ts. mertensiana, Ps. menziesii, A. grandis,* and *P. contorta* (43°63.52´N, 121°16.63´W, elev. 1935 m). **6c**: Paulina Creek Falls, mature conifer forest in deep river valley, with *Ts. mertensiana, Abies* sp., *P. monticola*, and *P. contorta* (43°62.77´N, 121°16.83´W, elev. ca. 1800 m).

G: Forests of northern and central California. — These forests comprise one of the most variable vegetation regions of western North America. They include the montane coniferous forests and woodlands of the Sierra Nevada and structurally similar forests in the Klamath-Siskiyou region of SW Oregon and NW California. In the Sierra Nevada coniferous forests cover most of both slopes at elevations between 500 and 3500 m.

Klamath forests. — The Klamath-Siskiyou region lies in a transition zone between the wet temperate climate of the western Pacific Northwest and a drier, more Mediterranean climate in the south. Summers are hot and dry, winters mild and moist. At higher elevations, much of the annual precipitation falls as snow. *Pseudotsuga menziesii*, *Pinus ponderosa* and *Calocedrus decurrens* dominate at many sites, with sclerophyllous trees and shrubs, like *Arbutus menziesii*, *Quercus chrysolepis*, and *Lithocarpus densiflorus* in the lower canopy. Forests on serpentine soils are sparse and stunted in comparison with those on non-serpentine soils. *Pinus jeffreyi* is the dominant tree on such sites, but also *Calocedrus decurrens* is common (Fig. 11). The understory is often dominated by sclerophyllous shrubs. A number of additional conifers, including *Pseudotsuga menziesii* and *Chamaecyparis lawsoniana*, occur on mesic and hygric sites.

OREGON. **1a–b**: Josephine Co.: Rough and Ready Creek watershed. **1a**: Rough and Ready Creek Forest Wayside State Park, open serpentine woodland with low *P. jeffreyi, C. decurrens, Q. garrayana*, and *Q. vaccinifolia* (42°05.4´N, 123°41.2´W, elev. ca. 400 m). **1b**: Near crossing of Forest Service Road 442, riparian serpentine forest with *P. jeffreyi, C. decurrens, Ps. menziesii*, and *C. lawsoniana*; also shrub-like *Q. garrayana, Q. vaccinifolia*, *Xerophyllum tenax, Arctostaphylos nevadensis,* and *Rhododendron occidentale* (42°05.1´N, 123°45.4´W, elev. ca. 520 m). **2**: CALIFORNIA. Siskiyou Co.: Moist old-growth forest with *C. lawsoniana*, *Ps. menziesii*, *Ts. heterophylla*, and *L. densiflorus*, dense understory of evergreen shrubs (61°15.02´N, 123°61.85´W, elev. 600 m). **3a–b**: Trinity Co.: Scott Mountain. **3a**: Semi-open mature conifer forest with *C. decurrens, Ps. menziesii*, and *P. ponderosa*, patchy understory of *Arctostaphylos* and other shrubs (41°16.38´N, 122°62.13´W, elev. ca. 1000 m). **3b**: Mature conifer forest with *C. decurrens, Ps. men-*

Fig. 12. Mixed conifer forest in the Sierra Nevada (Hull Creek, CA, survey site G6)

Fig. 13. *Pinus albicaulis* at upper timberline (Leavitt Lake, CA, survey site F9).

ziesii, and *P. ponderosa* (41°15.81´N, 122°61.67´W, elev. ca. 800 m). **4a–c**: Trinity Co.: Bear Gulch Trail (40°53´N, 123°01.3´W). **4a**: Stand of old-growth *Ps. menziesii* in mature conifer forest (elev. 1200 m). **4b**: Mature mixed forest with *Arbutus menziesii, Quercus chrysolepis, Ps. menziesii, C. decurrens*, and *P. ponderosa*, with dense shrubby understory (elev. 1650 m). **4c**: Trinity Co.: Ripstein Gulch. Mature mixed forest with *Ps. menziesii, Abies* sp., *A. menziesii, A. macrophyllum*, dense understory of shrubs (40°52.8´N, 123°01.67´W, elev. 880 m).

Sierra forests. — Temperate, oroboreal and subalpine forests and woodlands clothing most of the Sierra Nevada and the upper slopes of the White Mountains. The range of low elevation conifer forests in the northern and central Sierra Nevada is usually from 300 to 1800 m. The climate is relatively dry and hot, with most precipitation falling as winter rain. Forest composition varies widely depending on stand age and fire history. *Abies concolor* is usually dominant on mesic sites, while *Pinus ponderosa* or *P. jeffreyi* and *Calocedrus decurrens* characterize xeric localities (Fig. 12). Favorable sites on the western slope can support massive mixed conifer forests, with *Sequoiadendron giganteum* in local groves. At higher elevations the lower montane forests grade into upper montane forests. The lower and upper elevational limits of these forests are about 1800 m and 2700 m, depending on latitude and local conditions. Annual precipitation averages between 1000 and 1300 millimeters, most of which falls as snow. Many of these forests are dominated by *Abies magnifica*, but also *Pinus contorta*, *P. monticola*, and *P. jeffreyi* are important. *Pinus contorta* becomes more dominant towards the upper elevational limit of upper montane forests. The lower and upper limits of subalpine forests in the Sierra are usually about 2400 m and 3050 m. Typical tree species in these forests include *Pinus albicaulis*, *P. flexilis*, and *Tsuga mertensiana*. The most frequent tree line conifer is *P. albicaulis* (Fig. 13). Subalpine localities in the White Mountains, which lie just east of the Sierra Nevada, support open forests of *P. longaeva*. The lower slopes support *P. monophylla–Juniperus osteosperma* woodlands, that mix with shrub-steppe vegetation at the lower timberline. Similar woodland occur on the eastern flanks of the Sierra Nevada, between the *P. jeffreyi* dominated forests on upper slopes and *Artemisia* steppes on low-lying areas (Fig. 14).

CALIFORNIA. **5**: Calaveras Co.: Calaveras Big Tree State Park, South Grove Natural Preserve, along South Grove Trail, mixed forest dominated by *A. concolor*, *C. decurrens*, *P. lambertiana*, *P. ponderosa*, and *S. giganteum*, lower canopy of *Cornus nuttallii*, *C. cornuta*, and *Q. kelloggii* (37°15´N, 119°15´W, elev. 950 m). **6a–c**: Toulumne Co.: Stanislaus National Forest. **6a**: Hull Creek Campground, mature, moderately closed conifer forest with *A. concolor*, *P. contorta*, *P. jeffreyi*, *P. lambertiana*, and *C. decurrens* (38°06´N, 120°02´W, elev. 1600 m). **6b**: Trout Creek Over-

look, open woodland of *P. jeffreyi* and *C. decurrens* on top of serpentine ridge (38°07´N, 120°02´W, elev. 1700 m). **6c**: Clavey River, semi-open conifer forest with *P. jeffreyi*, *P. contorta*, and *A. concolor* (38°05´N, 120°00´W, elev. 1500 m). **7**: Mono Co.: Pacific Valley Campground, mature conifer forest (38°31´N, 119°53´W, elev. 2100 m). **8**: Alpine Co.: Grass Lake Mire, isolated *Pinus* stand in the middle of an open mire (38°47´N, 119°57´W, elev. 2200 m). **9a**–**b**: Mono Co.: Sonora Pass, Leavitt Lake. **9a**: Mature, semi-open *P. contorta* and *P. flexilis* forest (38°17´N, 119°37´W, elev. 2700 m). **9b**: *P. albicaulis* krummholz (38°16´N, 119°38´W, elev. 3300 m). **10**: Mono Co.: Convict Lake, open *P. jeffreyi* woodland; also *Populus* near the lake shore (37°35´N, 118°51´W, elev. 2400 m). **11**: Inyo Co.: Big Pine Creek, open conifer forest dominated by *P. jeffreyi* (37°08´N, 118°27´W, elev. 2600 m). **12**: Mono Co.: Schulman Grove. Ancient *Pinus longaeva* forest (37°23´N, 118°10´W, elev. 3100 m).

Fig. 14. *Pinus monophylla* at lower timberline (Toyabe National Forest, CA).

Field and laboratory work

Field surveys were focused on microhabitats and substrates that are known to support a high species richness and/or unusual species composition of calicioids. Such hotspots typically included the basal trunks of old, damaged trees, decorticated snags, hardwood twigs and crevices at the bases of overhanging rocks. When one calicioid species was found, the same microhabitat was searched until no more new species were detected, as far as one could determine with a hand lens in the field. All the specimens from one substate within a microhabitat (e.g., bark on the basal trunk of a tree) were pooled into one field collection. These collections were used as sample units in later analyses. Only trunks and branches that were accessible without climbing trees were sampled. In most cases the search was continued until all types of calicioid microhabitats within the site had been examined and some time had elapsed without encountering a new species.

In the laboratory the calicioid lichens and fungi were identified according to standard methods of herbarium taxonomy, including examination under dissecting and compound microscopes. In some cases micrographs were obtained using a Jeol JSEM-830 scanning electron microscope in the Institute of Biotechnology, Electron Microscopy unit, University of Helsinki. Ascospore, ascus and hyphal measurements were made from squash mounts of ascomata in water. Ascomata height, capitulum diameter, and stalk width were measured from dry ascomata under incident light. Specimens used for all measurements were chosen arbitrarily but without preconceived bias. Voucher specimens will be deposited at the Botanical Museum of the University of Helsinki (H) and other herbaria. Some specimens are scanty and only exist as semi-permanent slides.

Data analyses

All data analyses were performed using the statistical package PC-ORD (McCune & Medford 1995). The raw data matrix was 1008 field specimens × 82 calicioid species. Only presence or absence was recorded for each species in each sample unit. When analyzing regional patterns in calicioid communities the sample units were organized into eight classes corresponding to the major forest zones or zone complexes. When comparing calcioid communities of different substrates, the sample units were organized into several substrate classes. The presence or absence data within classes were converted to percentage frequencies.

Differences in species accumulation as a function of sample size (i.e., numer of field specimens) between different substrates and habitat classes were visualized with the help of species-area curves (McCune & Medford 1995).

The data set of each class was subsampled 500 times for all possible subsample sizes. Differences in species composition between different habitat and/or substrate classes were examined by cluster analyses. Groups were formed with Ward's method of clustering, using an Euclidean distance matrix (McCune & Medford 1995). Prior to an analysis of prevailing substrate types (conifer bark and conifer wood) from the different forest zones, all calicioid species that occurred in less than three habitat classes were removed, resulting in a matrix of 16 substrate classes × 50 species. This strengthened the apparent differences among habitat classes by reducing noise from infrequent species. The matrix was then relativized in order to relieve the effect of large differences in class totals. In another analysis, relations between frequent calicioid species with broad substrate tolerances were studied by cluster analysis of a transposed community matrix. Before the analysis all species that occurred in fewer than six habitat classes were removed. Also all resinicolous species, host-specific parasites, and taxonomically unresolved species complexes were removed, resulting in a matrix of 28 species × 26 habitat classes. The matrix was relativized by species sums of squares to de-emphasize clustering based on total abundance alone (McCune *et al*. 2000).

Non-metric multidimensional scaling (NMS) was used to produce graphical depictions of community relationships and habitat variables (forest zones and substrate classes in species space). NMS is a non-parametric ordination technique and well suited to data that are non-normal, are on discontinuous scales, and contain a large proportion of zero values (McCune & Medford 1995). In order to reduce noise from rare species, all calicioids which occurred in only one forest zone were deleted from the data sets prior to the analysis. The NMS ordinations were performed using the quantitative version of Sørenson's distance measure, 100 iterations, and random starting coordinates. The program was run several times with different starting configurations to ensure that the obtained minimum stress was not a local minimum. A two dimensional ordination of the data matrix was produced after determining that higher dimensional solutions did not substantially reduce stress. The stability of the solution was examined by plotting stress vs. iteration number, and the probability that a similar final stress could have been obtained by chance was determined by using a Monte Carlo test. Habitat variables were superimposed on the resulting ordination using a joint plot, based on the correlations of explanatory variables with the axes of the community ordination. For visual clarity, the ordination was rigidly rotated to load an interpretable environmental factor (elevation) on the vertical axis. Variance explained was expressed by the coefficient of determination between Euclidean distances in the ordination space and the Sørensen distances in the original species space (McCune & Medford 1995).

Results

Species list

Over 1400 specimens were collected from calicioid microhabitats during site surveys. In the laboratory 1008 of these were found to house calicioids. As many field specimens contained several species, a total of 2103 observations of calicioid lichens and fungi were made (Table 1). A total of 82 species were found, including seven taxa that have since been described as new (Peterson & Rikkinen 1998, Rikkinen 1999, 2003a, 2003b). Another 6–10 new taxa await formal description. In addition, hundreds of bark- and wood-inhabiting myxomycetes and non-calicioid ascomycetes were identified, but these will not be discussed further here (Ukkola & Rikkinen 2000, Rikkinen unpubl.).

In the list below, the genera of crustose calicioid lichens and fungi are listed alphabetically under each family; fruticose genera (*Bunodophoron*, *Sphaerophorus*) are not included in this study. The following species complexes, among others, remain inadequately understood and have been treated collectively: *Chaenotheca brunneola s. lato* (probably including *C. sphaerocephala* and undescribed taxa); *Chaenothecopsis pusilla s. lato* (including several undescribed taxa); and *Mycocalicium subtile s. lato* (possibly constituting a complex of closely related taxa).

Table 1. Basic statistics for sample units from the different forest zones. Samples: proportion (%) of all sample units by zone and substrate class. Obs: proportion (%) of species observations by zone and substrate class. Species no.: total number of calicioid species in zone or substrate class. Spec./sample: average number of calicioid species per sample. Beta div./sample: total number of species in substrate class divided by average number of species per sample. Spec./site: average number of calicioid species per collection site. Beta div./site: total number of species divided by average number of species per site. Elev: average elevation of survey sites within forest zone.

Forest zone (sample size)	Samples	Obs.	Species no.	Spec./ sample	Beta div./ sample	Spec./ site	Beta div./ site	Elev.
Coastal forests (187)	18.6	15.3	36	1.72	20.9	9.31	3.9	115 m
Conifer bark	66.3	73.0	28	1.90	14.7	6.62	4.2	
Conifer wood	27.3	23.3	23	1.47	15.6	3.50	6.6	
Hardwood bark	5.9	3.4	3	1.00	3.0	0.56	5.3	
Hardwood lignum	0.5	0.3	1	1.00	1.0	0.06	16.0	
Rock or detritus	–	–	–	–	–	–	–	
Tsuga heterophylla Zone (216)	21.4	20.8	51	2.02	25.2	13.31	3.8	395 m
Conifer bark	39.8	52.9	35	2.69	13.1	8.38	4.2	
Conifer wood	46.3	38.0	26	1.66	15.7	4.31	6.0	
Hardwood bark	7.4	4.1	7	1.12	6.2	1.00	7.0	
Hardwood lignum	2.3	2.0	7	1.80	3.9	0.54	13.0	
Rock or detritus	4.2	3.0	5	1.44	3.5	0.38	13.0	
Valley foothills (99)	9.8	12.2	45	2.58	17.4	26.25	1.7	181 m
Conifer bark	51.5	63.7	30	3.18	9.4	17.25	1.7	
Conifer wood	28.3	24.2	24	2.21	10.8	9.25	2.6	
Hardwood bark	9.1	3.9	6	1.11	5.4	1.75	3.4	
Hardwood lignum	11.1	8.2	13	1.91	6.8	4.25	3.1	
Rock or detritus	–	–	–	–	–	–	–	
Valley bottomland (98)	9.7	9.9	34	2.31	14.7	14.33	2.4	126 m
Conifer bark	15.3	24.5	12	3.40	3.5	3.50	3.4	
Conifer wood	9.2	9.6	9	2.22	4.1	2.00	4.5	
Hardwood bark	39.8	26.0	18	1.38	13.0	4.67	3.9	
Hardwood lignum	35.7	39.9	24	2.37	10.1	8.17	2.9	
Rock or detritus	–	–	–	–	–	–	–	
Cascades, W slope (114)	11.3	12.1	43	2.24	19.2	13.89	3.1	1230 m
Conifer bark	37.7	42.3	24	2.51	9.6	7.33	3.3	
Conifer wood	57.9	55.3	33	2.14	15.4	8.56	3.9	
Hardwood bark	4.4	2.4	5	1.2	4.2	0.67	7.5	
Hardwood lignum	–	–	–	–	–	–	–	
Rock or detritus	–	–	–	–	–	–	–	
Cascades, E slope (104)	10.3	11.7	44	2.37	18.6	14.50	3.0	1242 m
Conifer bark	31.7	35.2	20	2.64	7.6	6.62	3.0	
Conifer wood	52.9	57.9	34	2.60	13.0	9.25	3.7	
Hardwood bark	10.6	4.5	3	1.00	3.0	0.75	4.0	
Hardwood lignum	1.9	0.8	2	1.00	3.0	0.25	8.0	
Rock and detritus	2.9	1.6	2	1.33	1.5	0.37	5.3	
Subalpine forests (73)	7.2	7.2	27	2.07	13.0	8.75	3.1	1686 m
Conifer bark	34.2	44.3	18	2.68	6.7	4.00	4.5	
Conifer wood	63.0	53.0	20	1.74	11.5	6.00	3.3	
Hardwood bark	–	–	–	–	–	–	–	
Hardwood lignum	1.4	0.7	1	1.00	1.0	0.12	8.0	
Rock and detritus	1.4	2.0	3	3.00	1.0	0.37	8.0	
Klamath and the Sierra (117)	11.6	10.9	42	1.96	21.4	9.00	4.7	1155 m
Conifer bark	35.0	47.6	26	2.65	9.8	5.27	4.9	
Conifer wood	54.7	44.5	28	1.59	17.6	4.73	5.9	
Hardwood bark	5.1	3.9	6	1.50	4.0	0.64	9.4	
Hardwood lignum	4.3	3.5	5	1.60	3.1	0.55	9.2	
Rock and detritus	0.9	0.4	1	1.00	1.0	0.19	5.5	
Total (1008)	100	100	82	2.1	39.0	12.31	6.7	

Some undescribed species are included in the list and their features are shortly described, pending formal description.

Numbers in bold after species names refer to collecting sites. The substrate data are given in abbreviated form: host species/tree type/microhabitat/substrate. Acronyms of host plants are: ABAM, *Abies amabilis*; ABCO, *Abies concolor*; ABGR, *Abies grandis*; ABLA, *Abies lasiocarpa*; ABPR, *Abies procera*; ABSP, *Abies* sp.; ACCI, *Acer circinatum*; ACMA, *Acer macrophyllum*; ALRU, *Alnus rubra*; ALSI, *Alnus sinuata*; AMSP, *Amelanchier* sp.; ARME, *Arbutus menziesii*; BRSP, broadleaved tree; CADE, *Calocedrus decurrens*; CELE, *Cercocarpus ledifolius*; CHLA, *Chamaecyparis lawsoniana*; CHNO, *Chamaecyparis nootkatensis*; COCO, *Corylus cornuta*; COSP, conifer sp.; FRLA, *Fraxinus latifolia*; JUOC, *Juniperus occidentalis*; LAOC, *Larix occidentalis*; LIDE, *Lithocarpus densiflorus*; PHSP, *Philadelphus* sp.; PIEN, *Picea engelmannii*; PISI, *Picea sitchensis*; PIAL, *Pinus albicaulis*; PICO, *Pinus contorta*; PIFL, *Pinus flexilis*; PIJE, *Pinus jeffreyi*; PILA, *Pinus lambertiana*; PILO, *Pinus longaeva*; PIMO, *Pinus monticola*; PIMU, *Pinus muricata*; PIPO, *Pinus ponderosa*; POTR, *Populus trichocarpa*; PSME, *Pseudotsuga menziesii*; QUCH, *Quercus chrysolepis*; QUGA, *Quercus garrayana*; RHPU, *Rhamnus purshiana*; SARA, *Sambucus racemosa*; SASP, *Salix* sp.; SESE, *Sequoia sempervirens*; SEGI, *Sequoiadendron giganteum*; SOSI, *Sorbus sitchensis*; TABE, *Taxus brevifolia*; THPL, *Thuja plicata*; TODI, *Toxicodendron diversiloba*; TSHE, *Tsuga heterophylla*, and TSME, *Tsuga mertensiana*. Abbreviations of host types are: lt, living tree; dt, dead tree; log, log; sn, snag; fp, fence post; stn, natural stump, and stc, cut stump. Abbreviations of microhabitats are: tr, trunk; trc trunk crevice; trb, trunk base; trbc, trunk base crevice; br, branch; tw, twig; and ro, exposed root. All substrates have been pooled either into bark, wood, resin, rock or detritus, which are abbreviated b, w, re, rock and detr, respectively.

Most of the specimens are kept in Helsinki (H). In herbarium specimens the listed collection number is preceded by JRC 9, with C indicating a specimen of calicioid fungi.

Caliciaceae

Calicium abietinum Pers. — Infrequent over hard lignum at lower elevations. Also on stringy bark of *Thuija plicata* and similar conifers. Total 15 specimens.

A5b: PISI/sn/tr/w, 8159. **A9**: SESE/lt/tr/b, 8232. **B2b**: FRLA/sn/tr/w, 7176. **C1**: ABGR/stn/trb/w, 8027. **C3**: TABE/sn/tr/w, 7337–7340. **C4**: ACMA/sn/tr/w, 8428. **D2**: COSP/sn/tr/w, 6125. **D7**: COSP/sn/tr/w, 6102. **E2**: COSP/sn/tr/w, 6097. **E4**: PIPO/log/tr/w, 8562. **E6**: COSP/sn/tr/w, 8312. **G4a**: PSME/lt/tr/w, 7069.

Calicium adaequatum Nyl. — Frequent over twigs and thin branches of hardwoods. This seems to be a complex of two taxa. All specimens have pale, olivaceous stalks and brownish capitula, an I+ dark blue color reaction of the stalk and excipulum, and ascospores with a distinctive spiral ornamentation. Some specimens have tiny ascomata and relatively short spores (7–11 μm long). Other specimens have relatively robust ascomata and the ascospores, when mature, are larger (10–16 μm long). In such specimens the isodiametric cells in the outermost part of the excipulum can be up to 7 μm in diam. The difference in spore size does not seem to be adequately explained by differences in the age of measured spores (Tibell 1975). The small form is common, though easily overlooked, over branches of hardwoods at low elevations. It is particularly common on twigs of aged *Quercus garrayana* in the Willamette Valley. The robust form appears to be more confined to montane forests, where it grows on branches and twigs of deciduous trees and shrubs, but also on smooth bark of *Abies* species. Total 28 specimens.

B1: POTR/lt/tw/b, 8202. **B2b**: FRLA/lt/tw/b, 8497. **C6**: ACMA/lt/tw/b, 7199, 7204, 7216, 7217. **C7b**: QUGA/lt/tw/b, 7232A, 7232B. **C8a**: COCO/lt/tw/b, 7114. FRLA/lt/tw/b, 7108. **C8b**: FRLA/lt/tw/b, 8049, QUGA/lt/tw/b, 8033, 8050. **E1**: ALRU/dt/tr/b, 6058A, 6058B. **E3b**: ALSI/lt/tw/b, 8546, POTR/lt/tw/b, 8527. **E4**: ALSI/lt/br/b, 8572, AMSP/lt/tw/b, 8564, PHSP/lt/tw/b, 8558, SOSI/lt/br/b, 8574. **E5**: ABGR/lt/tr/b, 8587. **E6**: ACCI/lt/tw/b, 8330. **F6c**: ABSP/lt/tr/b, 8625. **G1a**: QUGA/lt/tw/b, 8051, 8052. **G1b**: QUGA/lt/tw/b, 8054. **G4c**: ACMA/lt/tw/b, 7076.

Calicium adspersum Pers. — Rare over conifer bark in humid forests at low elevations (Peterson & Rikkinen 1999). Total four specimens.

A9: SESE/lt/tr/b, 8232. **B1**: PSME/lt/tr/b, 8207. **C1**: PSME/lt/tr/b, 8022. **C4**: ABGR/dt/tr/b, 8426.

Calicium corynellum (Ach.) Ach. — Rare, found twice over vertical rock in shady caverns of an ancient lava flow. Probably a widespread but overlooked species in rocky areas at higher elevations in the Cascades. Total two specimens.

E4: ROCK/-/-/rock, 8557, 8559.

Calicium glaucellum Ach. — Frequent over wood and bark of conifers in montane forests and in the Willamette Valley. Also on exposed snags near the Pacific Coast, but largely absent from closed low-elevation rainforests. A variable taxon with respect to ascoma size and pruinosity. Some epruinose, small specimens on conifer bark may belong to *Calicium pinastri* Tibell. Total 121 specimens.

A5b: PISI/sn/tr/w, 8159, 8160. **A9**: SESE/lt/tr/b, 8229, 8234. **A12**: PIMU/lt/tr/b, 2064. **B2b**: FRLA/sn/tr/w, 7176. **B3**: COSP/stc/tr/w, 7178. **B4**: PSME/lt/tr/b, 8289. **B5**: PSME/lt/tr/b, 8123. **B8**: THPL/lt/tr/b, 6014. **B9**: PSME/sn/tr/w, 8468. **B10a**: COSP/sn/tr/w, 6114. **C1**: ABGR/stn/trb/w, 8027. PSME/lt/tr/b, 8019, 8020. **C3**: ABGR/lt/tr/b, 8369, 8370. **C4**: PSME/lt/tr/b, 8416. **C5**: QUGA/sn/tr/w, 7171. **C6**: COSP/fp/tr/w, 7193. PSME/stc/trb/w, 7190. PSME/lt/tr/b, 7192, 7221. QUGA/log/br/w, 7198. QUGA/stn/tr/w, 7289. **C7b**: ABSP/lt/tr/b, 7248. **C8a**: ABSP/lt/trb/b, 7120. PSME/lt/tr/b, 7115, 7116. PSME/lt/trbc/b, 7123. QUGA/sn/tr/w, 7111. **C8b**: QUGA/lt/trc/w, 8030. QUGA/lt/tr/b, 8031. QUGA/sn/trc/w, 8037. **D1a**: ABPR/sn/tr/w, 7002, 7004, 7013B, 7019, 7020, 7022, 7024B. ABPR/dt/tr/b, 7018. ABPR/sn/tr/b, 7023. **D2**: ABSP/lt/tr/b, 6142. COSP/sn/tr/w, 6124, 6125, 6130, 6145. **D3a**: COSP/sn/tr/w, 6039. PSME/stn/tr/w, 6024. **D3b**: ABSP/sn/tr/w, 6051A. COSP/sn/tr/w, 6041. **D4**: ABSP/sn/tr/w, 8668, 8675. **D5**: PSME/sn/tr/w, 7050B. PSME/lt/br/w, 7047A. **D6a**: PICO/lt/br/w, 7027, 7028. PSME/log/tr/w, 7026. **D6b**: PSME/stn/trb/w, 7031A. PSME/sn/tr/w, 7034. PSME/lt/tr/b, 7037. **D7**: COSP/sn/tr/w, 6102. **E1**: COSP/sn/tr/w, 6059. **E2**: COSP/sn/tr/w, 6091, 6097. PSME/dt/tr/b, 6093. **E3a**: ABSP/sn/tr/w, 8519. COSP/sn/tr/w, 8523. PSME/sn/tr/w, 8510, PSME/lt/tr/b, 8513, 8515, 8520. TSME/lt/trc/b, 8525. **E3b**: ABSP/sn/tr/w, 8529. ABSP/dt/trc/w, 8530. PIEN/lt/tr/b, 8545. PIMO/sn/tr/w, 8539. **E3b**: PSME/sn/tr/w, 8528, 8532. **E4**: ABSP/lt/tr/b, 8575. LAOC/dt/tr/w, 8577. PIPO/log/tr/w, 8562. PIPO/sn/tr/w, 8563. PSME/lt/tr/b, 8573. **E6**: COSP/sn/tr/w, 8312. PIPO/sn/tr/w, 8313–8315, 8323, 8327, 8329. PIPO/sn/trb/w, 8318. PIPO/log/tr/w, 8328. PSME/stn/tr/b, 8320. **F2**: ABSP/stn/trb/w, 8644, 8645. ABSP/sn/trb/w, 8647A, 8648. ABSP/sn/tr/w, 8651, 8654. ABSP/sn/trb/b, 8647B. TSME/lt/tr/b, 8655. **F3**: COSP/sn/tr/w, 7040, 7041. **F4**: COSP/sn/tr/w, 8549, 8551. **G1b**: CADE/sn/tr/w, 8068. COSP/lt/tr/b, 8073. COSP/sn/tr/w, 8075. COSP/sn/trc/w, 8076. PIPO/sn/trbc/w, 8057. PIPO/sn/tr/w, 8065. PSME/sn/tr/b, 8071B. **G2**: LIDE/sn/tr/b, 7086. **G3b**: CADE/lt/trb/w, 7062. **G4a**: PSME/lt/tr/b, 7067, 7069. PSME/stc/tr/w, 7070. **G4b**: PSME/sn/tr/w, 7071. **G5**: ABCO/lt/tr/b, 2052.

Calicium lenticulare Ach. — Locally frequent over wood and bark in low-elevation rainforests. Prefers large conifer snags in very humid old-growth forests. Often heavily infected by *Asterophoma mazaedicola*, which may be the coelomycetous anamorph of *Chaenothecopsis savonica* (Hawksworth 1981, Tibell 1991b, 1997). Total 36 specimens.

A2b: PISI/sn/tr/w, 7138, 7137. **A3a**: THPL/lt/tr/b, 8356. **A3b**: PSME/lt/tr/b, 8464, 8463. PISI/sn/tr/b, 8462. **A5a**: PSME/sn/tr/w, 8157. **A6a**: COSP/stn/tr/w, 8170, 8169. COSP/stn/trb/w, 8167. **A7b**: PSME/lt/trb/b, 8261. **A8**: TSHE/lt/tr/b, 8096. THPL/lt/tr/b, 8098. PSME/lt/tr/b, 8089. PSME/sn/tr/w, 8103. **A9**: SESE/lt/tr/b, 8224. **A10b**: SESE/lt/tr/b, 7105, 7100. **B4**: THPL/lt/tr/b, 8305. **B6**: PSME/sn/tr/w, 8387, 8384, 8381, 8374. **B7**: THPL/lt/tr/b, 8281. THPL/sn/tr/w, 8282. PSME/sn/tr/w, 8407, 8406, 8402, 8401, 8399, 8279, 8270. COSP/sn/tr/w, 8284, 8283. **B8**: COSP/sn/tr/w, 6020. **B10a**: THPL/lt/tr/b, 6112.

Calicium cf. *parvum* Tibell — Rare over conifer bark and wood. Characterized by its relatively small (8–10 μm long) spores and clavate asci. This taxon should be compared with European specimens when more material becomes available. Total five specimens.

C3: PSME/lt/tr/b, 7335. **E6**: PIPO/sn/tr/w, 8313, 8329. **G1b**: CHLA/lt/tr/b, 8072B. COSP/lt/tr/b, 8073.

Calicium salicinum Pers. — Locally frequent over hardwood lignum in the Willamette Valley (Rikkinen 1998). Total 25 specimens.

C3: TABE/sn/tr/w, 7337, 7340. **C4**: ACMA/sn/tr/w, 8421. **C5**: QUGA/sn/tr/w, 7168, 7170, 7171, 7174. QUGA/lt/trc/w, 7169. **C6**: QUGA/lt/br/b, 7219. QUGA/sn/tr/w, 7195, 7223, 7227. QUGA/stn/tr/w, 7289. **C7a**: ACMA/stn/trbc/w, 7208. ACMA/lt/trbc/w, 7215. **C8a**: QUGA/sn/tr/w, 7109–7112. QUGA/sn/trbc/w, 7122. **C8b**: FRLA/stn/tr/w, 8042. FRLA/lt/trbc/w, 8046. QUGA/sn/trc/w, 8037. **E1**: THPL/lt/tr/b, 6071. **G5**: SEGI/lt/trc/w, 2060.

Calicium viride Pers. — Frequent over bark and wood of conifers in montane forests and in the Willamette Valley. Prefers semi-open forests and is more or less absent from the basal trunks of conifers in low-elevation rainforests. Total 89 specimens.

B9: PSME/lt/tr/b, 8474. **C1**: ABGR/lt/tr/b, 8023, 8026. PSME/lt/tr/b, 8005, 8018. PSME/sn/tr/b, 8017. **C3**: ABGR/lt/tr/b, 8370. **C4**: ABGR/dt/tr/b, 8417, 8426, 8427. **C6**: PSME/lt/tr/b, 7221, 7225. **C8a**: ABSP/lt/trb/b, 7120. PSME/lt/tr/b, 7115. **D1a**: ABPR/dt/tr/b, 7006. ABPR/sn/tr/b, 7023. **D2**: ABSP/lt/tr/b, 6135, 6136, 6142. PSME/lt/trb/b, 6141, 6143. **D3a**: PSME/stn/tr/w, 6024. PSME/lt/tr/b, 6030. **D3b**: ABSP/lt/tr/b, 6044. ABSP/sn/tr/w, 6051A, 6051C. ABSP/sn/tr/b, 6051B. **D4**: TSHE/lt/trbc/w, 8656. **D5**: PSME/lt/tr/b, 7043, 7047B. TSHE/lt/tr/b, 7045. **E1**: ABSP/lt/tr/b, 6060. PSME/lt/tr/b, 6068. THPL/lt/tr/b, 6061, 6065, 6071. **E2**: COSP/sn/tr/w, 6078. **E3a**: PIEN/lt/trbc/b, 8521. **E3b**: PSME/lt/tr/b, 8540. **E4**: ABSP/lt/tr/b, 8575. COSP/sn/tr/w, 8570. LAOC/dt/tr/w, 8577. PSME/lt/tr/b, 8569. **E5**: ABGR/lt/tr/b, 8588. PIPO/sn/tr/w, 8583. **E6**: ABSP/dt/tw/w, 8324. ABSP/dt/trb/b, 8325. PIPO/sn/tr/w, 8313. PSME/stn/tr/b, 8320. PSME/lt/tr/b, 8331. **F2**: ABSP/sn/trb/b, 8647B. CHNO/lt/tr/b, 8646, 8650. **F6a**: TSME/lt/tr/b, 8606–8608. **F6b**: ABGR/lt/br/b, 8612, 8613. ABGR/lt/tr/b, 8615. PSME/dt/br/b, 8611. TSME/lt/trbc/w, 8618A. **F6c**: ABSP/lt/tr/b, 8626, 8627. PIMO/lt/tr/b, 8629, 8631. PIMO/lt/trbc/b, 8632. TSME/dt/trbc/w, 8624C. **G1b**: CHLA/lt/tr/b, 8072B. **G3a**: CADE/sn/trb/w, 7060. **G3b**: CADE/lt/trb/w, 7061, 7062. PSME/lt/trb/b, 7063. **G4a**: PSME/lt/tr/b, 7065, 7067, 7069. PSME/sn/tr/b, 7066. **G5**: ABCO/lt/tr/b, 2052, 2053. SEGI/lt/trc/w, 2056, 2060. **G6a**: ABCO/lt/tr/b, 2001, 2006. ABCO/stc/trb/w, 2010. **G6c**: ABCO/ lt/tr/b, 2013A, 2018, 2020, 2027, 2028. ABCO/ sn/tr/b, 2021.

Calicium sp. 1 — Frequent over wood and bark in semi-open forests at lower elevations, particularly in the foothill forests of the Willamette Valley. Not as common at higher elevations, where largely replaced by *C. glaucellum*. Resembles *C. glaucellum*, but has an intensely red pigment bleeding from the excipulum and upper part of the stalk in KOH. The pigment occurs as small crystals in the hyaline sheath of the excipulum, bleeds into the medium and is quite persistent, only slowly turning into a dull brown. The mazaedium and basal stalk often bleed an equally persistent, olivaceous pigment in KOH. Mature ascospores are larger than in *C. glaucellum*, measuring 13–16 × 6–8 μm, and have a rough surface ornamentation. Mature asci cylindrical, 50–55 μm long. Total 40 specimens.

A1: PISI/sn/tr/w, 8445. **B5**: PSME/sn/tr/w, 8105, 8106, 8117, 8127, 8129. PSME/lt/tr/b, 8131. **B7**: PSME/lt/tr/b, 8398. **B9**: PSME/stn/tr/w, 8467. PSME/sn/tr/w, 8468, 8469. **C1**: ABGR/lt/tr/b, 8007. COSP/stn/tr/w, 8003. COSP/stn/trbc/w, 8009. COSP/sn/tr/w, 8013, 8014. PSME/dt/tr/b, 8002. PSME/lt/tr/b, 8005, 8006. **C3**: ABGR/lt/trb/w, 8361. **C4**: ABGR/dt/tr/b, 8417. ABGR/lt/tr/b, 8419. **C8b**: COSP/stc/tr/w, 8048. **D4**: TSHE/lt/trbc/w, 8660. TSHE/lt/trbc/b, 8661. TSHE/lt/tr/b, 8673. TSHE/sn/tr/w, 8676. **E3a**: ABSP/sn/tr/w, 8512, 8519. **E4**: PIPO/sn/tr/w, 8563. **E5**: PIPO/sn/tr/w, 8581. **F4**: COSP/sn/tr/w, 8551. **F6b**: ABGR/lt/br/b, 8613. COSP/sn/tr/w, 8610. **F6c**: TSME/sn/tr/w, 8630. **G1b**: CADE/lt/trc/w, 8055. COSP/sn/tr/w, 8075. PIPO/sn/tr/w, 8065, 8081. PSME/lt/tr/b, 8083.

Cyphelium inquinans (Sm.) Trevis — Frequent over bark and wood of conifers in montane forests and in the Willamette Valley. Prefers semi-open forests, but also grows on basal trunks of conifers in closed low-elevation rainforests. Total 131 specimens.

A3a: PSME/lt/tr/b, 8336, 8337, 8338. **A3b**: PSME/lt/tr/b, 8458, 8463, 8465. **A7b**: PSME/lt/tr/b, 8263. **A8**: PSME/lt/tr/b, 8088. **B1**: PSME/lt/tr/b, 8205B, 8207, 8222, 8212. **B2a**: PSME/lt/tr/b, 7165. **B2b**: FRLA/sn/tr/w, 7176. **B4**: PSME/lt/tr/b, 8289, 8306. THPL/lt/tr/b, 8291, 8308. **B7**: PSME/lt/tr/b, 8400, 8404. **B9**: PSME/lt/tr/b, 8470, 8471, 8472, 8474, 8475, 8478. TSHE/lt/tr/b, 8493, 8494, 8495. **C1**: ABGR/lt/tr/b, 8023. COSP/sn/tr/w, 8013, 8028. PSME/lt/trb/b, 8016. PSME/lt/tr/b, 8018. PSME/sn/tr/b, 8017, 8022. **C2**: PSME/lt/tr/b, 7260, 7282. **C3**: ABGR/lt/trb/w, 8361. PSME/lt/tr/b, 7330, 7335. **C4**: ABGR/lt/tr/b, 8419. ABGR/dt/tr/b, 8426, 8427. PSME/lt/tr/b, 8416, 8424, 8425. **C6**: PSME/lt/tr/b, 7192, 7221, 7224, 7225, 7226. QUGA/sn/tr/w, 7227. **C8a**: ABSP/lt/trb/b, 7120. PSME/lt/tr/b, 7115, 7116, 7118. QUGA/dt/trbc/w, 7124. **C8b**: COSP/fp/tr/w, 6007, 8035, 8036, 8040. COSP/stc/tr/w, 8048. QUGA/dt/tr/w, 6009. **D1a**: ABPR/dt/tr/b, 7006. ABPR/sn/tr/b, 7023. **D2**: COSP/sn/tr/w, 6145. PSME/lt/trb/b, 6141. **D3a**: PSME/stn/tr/w, 6024. PSME/lt/tr/b, 6030. **D3b**: ABSP/sn/tr/w, 6051C. COSP/sn/tr/w, 6041. **D4**: TSHE/lt/trbc/w, 8656, 8660. TSHE/lt/tr/b, 8672, 8673. **D5**: PSME/lt/tr/b, 7043. TABE/lt/br/w, 7046. TSHE/lt/tr/b, 7045. **D6a**: PSME/log/tr/w, 7026. **E1**: ABSP/lt/tr/b, 6060. THPL/lt/tr/b, 6061, 6065, 6071. **E2**: COSP/sn/tr/w, 6078, 6091. PSME/dt/tr/b, 6093. **E3b**: PIEN/lt/tr/w, 8537. PIEN/lt/tr/b, 8545. **E4**: ABSP/lt/tr/b, 8575. COSP/sn/tr/w, 8570. LAOC/dt/tr/w, 8577. LAOC/dt/tr/b, 8578. PSME/lt/tr/b, 8569, 8573. **E5**: ABGR/lt/tr/b, 8588. **E6**: ABSP/dt/tw/w, 8324. COSP/sn/tr/w, 8312. PIPO/sn/tr/w, 8315, 8323, 8327. PSME/stn/tr/b, 8320. PSME/lt/tr/b, 8331. **F2**: ABSP/sn/trb/w, 8648. CHNO/lt/tr/b, 8646. **F4**: COSP/sn/tr/w, 8551. **F6b**: ABGR/lt/tr/b, 8615. COSP/sn/tr/w, 8610. **F6c**: ABSP/lt/tr/b, 8627. TSME/sn/tr/w, 8630. **G1b**: CADE/sn/tr/w, 8068. COSP/lt/tr/b, 8074. PSME/log/br/w, 8067. PSME/lt/tr/b, 8070. PSME/sn/tr/b, 8071B. **G3a**: CADE/sn/br/w, 7058, 7060. PSME/sn/trb/b, 7053. **G3b**: CADE/lt/trb/w, 7061, 7062. **G4a**: PSME/lt/tr/b, 7065, 7067. **G4c**: PSME/lt/tr/b, 7083. **G5**: ABCO/lt/tr/b, 2052, 2053. SEGI/log/trb/w, 2051B. SEGI/lt/trc/w, 2054, 2060.**G6a**: ABCO/lt/tr/b, 2001. ABCO/lt/br/b, 2006. **G6c**: ABCO/sn/tr/b, 2021.

Cyphelium karelicum (Vain.) Räsänen — Rare, found only once growing on hard lignum in a deep fire scar on the basal trunk of *Sequoiadendron giganteum*. Total one specimen.

G5: SEGI/lt/trc/w, 2060.

Cyphelium pinicola Tibell — Frequent over hard lignum and old bark of conifers in dry montane forests. Also in very exposed habitats in open low-elevation forests. Total 18 specimens.

E4: PIPO/sn/tr/w, 8566, 8560. PSME/lt/tr/b, 8573. **E5**: PIPO/sn/tr/w, 8581. **E6**: COSP/sn/tr/w, 8312. PIPO/sn/tr/w, 8327. PSME/lt/tr/b, 8331. **E7**: JUOC/lt/br/w, 8600, 8599, 8598. JUOC/sn/br/w, 8597. **F5**: PIAL/lt/trc/w, 8592. **F6b**: COSP/sn/tr/w, 8610. TSME/lt/trbc/w, 8618B. **G1b**: CADE/sn/tr/w, 8068. **G3a**: CADE/sn/trb/w, 7059. CADE/sn/br/w, 7058. **G6b**: PIJE/sn/tr/w, 2012.

Thelomma ocellatum (Körb.) Tibell — Infrequent (probably overlooked) on hard conifer lignum, including fence posts and other worked wood. Clearly nitrophilous, being largely restricted to bird perches (McCune & Rosentreter 1995). Total four specimens.

G1b: CADE/sn/tr/w, 8068. **G3a**: COSP/sn/tr/w, 7051. CADE/sn/br/w, 7058. CADE/sn/trb/w, 7059.

Thelomma occidentale (Herre) Tibell — Infrequent (possibly overlooked) on hard conifer lignum, including fence posts and other worked wood. Total three specimens.

A13a: COSP/fp/tr/w, 2062. **A15**: COSP/fp/tr/w, 2072. **G6b**: PIJE/sn/tr/w, 2012.

Tholurna dissimilis (Norman) Norman — Rare, found only once growing on the top branches of a stunted *Abies lasiocarpa* at the summit of Black Butte (elev. 1960 m). Usually grows on krummholz trees in subalpine forests, but has also been found on dead treetops of upper canopy conifers at lower elevations (McCune *et al*. 2000). Total one specimen.

F5: ABLA/lt/br/b, 8595.

Coniocybaceae

Chaenotheca brachypoda (Ach.) Tibell — Frequent over wood and bark in sheltered, humid microhabitats, often growing on soft lignum in trunk base hollows. Most frequent on aged hardwoods in the Willamette Valley (Rikkinen 1998, Peterson & Rikkinen 1999). Total 28 specimens.

A3b: TSHE/lt/trc/w, 8456. **B7**: THPL/lt/tr/b, 8281. THPL/lt/tr/w, 8281. **C1**: ACMA/sn/tr/w, 8011. **C3**: ACMA/dt/trbc/w, 7343. ABGR/lt/trb/w, 8358. FRLA/lt/tr/b, 8366. **C6**: QUGA/log/trbc/w, 7197. **C7a**: ACMA/lt/tr/w, 7167. ACMA/lt/trbc/b, 7210. ACMA/lt/trbc/w, 7215. ACMA/sn/trbc/w, 7207. **C8b**: TODI/dt/tr/b, 8038. FRLA/lt/trb/w, 8044. FRLA/lt/trb/b, 8045. ACMA/sn/tr/w, 8047. FRLA/stn/tr/w, 8042. **D1a**: ABPR/dt/trbc/b, 7007A. ABPR/dt/trbc/w, 7007B. ABPR/sn/trbc/w, 7011, 7013A. **D4**: TSHE/lt/trbc/w, 8667, 8677. **E2**: COSP/sn/tr/w, 6078. CHNO/lt/tr/b, 8650. CHNO/sn/trb/w, 8643. **F4**: ABSP/dt/trbc/w, 8552. **F6b**: TSME/lt/trbc/w, 8617.

Chaenotheca brunneola (Ach.) Müll. Arg. — Frequent over bark and wood in humid forests. This is an as yet unresolved complex of three or more species. Some specimens correspond well with *Chaenotheca brunneola s. str.* in having an immersed thallus, shiny black stalks and dark brown mazaedia. Such specimens are frequent in montane forests and in the Willamette Valley. Specimens from low elevation rainforests are quite variable and often difficult. Photobiont identity is not easily determined, as several types of green algae are often present in the substratum. In this treatment, specimens with a greenish, partly immersed thallus, robust ascomata with a well developed excipulum, and non-catenulate asci, have been separated into *Chaenotheca hygrophila*. Other specimens have an immersed or more minutely granular thallus, relatively slender ascomata, small (3.5–4.5 μm) spores, and catenulate asci. They correspond well with *Chaenotheca sphaerocephala*, except in often having a rather well developed excipulum. Some specimens, mostly from coastal forests, have small ascomata, cup-like excipula and tiny spores (2.5–3.5 μm). The smooth, pale spores give their mazaedia a characteristic, silvery-grey color. Total 216 specimens.

A1: PISI/sn/tr/w, 8444, 8451. TSHE/sn/tr/w, 8450. **A2a**: PISI/sn/tr/w, 7129. **A2b**: PISI/sn/tr/w, 7135, 7137. **A3a**: PISI/stc/tr/w, 8339. THPL/lt/tr/b, 8356. **A4**: PISI/lt/tr/b, 7306, 7316, 7319. **A5a**: PSME/lt/trb/b, 8151. PSME/sn/tr/w, 8156. **A5b**: PISI/sn/tr/w, 8161. **A6a**: COSP/stn/tr/w, 8169. PISI/lt/tr/b, 8162, 8166, 8173, 8175. PSME/lt/tr/b, 8168, 8174. **A6b**: PISI/lt/tr/b, 8186. PISI/lt/trb/b, 8180. THPL/lt/tr/b, 8178. THPL/stn/tr/w, 8177. **A7b**: PSME/lt/tr/b, 8257, 8268. PSME/lt/trb/b, 8261. TSHE/lt/tr/b, 8265. **A8**: PISI/lt/trbc/b, 8101, 8100. PSME/sn/tr/w, 8103. THPL/lt/tr/b, 8098. **A9**: SESE/lt/tr/b, 8224, 8227–8230, 8232–8235. **A10a**: PSME/lt/tr/b, 8246. SESE/lt/trbc/w, 8236–8239, 8241, 8243. **A10b**: SESE/lt/tr/b, 7099, 7101–7104. **B1**: PSME/lt/

tr/b, 8207, 8215, 8222. PSME/sn/tr/w, 8218. ROCK/-/-/rock, 8221. THPL/lt/tr/b, 8212, 8220. THPL/sn/tr/w, 8219. **B2a**: PSME/lt/tr/b, 7165. THPL/lt/tr/b, 7160, 7163, 7164. THPL/lt/trbc/b, 7162. **B2b**: FRLA/sn/tr/w, 7176. PSME/dt/trbc/w, 8502. PSME/sn/tr/w, 8498. **B2c**: PSME/sn/tr/w, 8294, 8296, 8300, 8305, 81353, 83482, 83486. **B3**: COSP/stc/tr/w, 7178. **B4**: PSME/lt/tr/b, 8306, 8304. PSME/sn/tr/w, 8290. THPL/lt/tr/b, 8285, 8287, 8297, 8308. THPL/lt/tr/w, 8286. **B5**: ALRU/sn/trb/w, 8115. PSME/lt/tr/b, 8113, 8121, 8123, 8124, 8131. PSME/sn/tr/w, 8105, 8106, 8127. **B6**: PSME/sn/tr/w, 8375, 8380, 8382, 8386–8389. **B7**: COSP/sn/tr/w, 8283. PSME/lt/tr/b, 8271, 8272, 8397, 8398, 8408, 8409. PSME/sn/tr/w, 8275, 8274, 8273. THPL/lt/tr/b, 8281. **B8**: COSP/sn/tr/w, 6020. PSME/sn/tr/w, 6016, 6018, 6019, 6022. **B9**: PSME/sn/tr/b, 8479. **B10a**: COSP/sn/tr/w, 6114. THPL/lt/tr/b, 6106, 6111. **B10b**: PSME/sn/tr/w, 6116, 6117, 6119, 6120. **C1**: ABGR/lt/tr/b, 8023. ABGR/stn/trb/w, 8027. COSP/sn/tr/w, 8013. COSP/stn/tr/w, 8003. PSME/lt/tr/b, 8019, 8020, 8022. **C2**: ABSP/lt/tr/b, 7238, 7239. PSME/lt/tr/b, 7336. PSME/sn/tr/w, 7237. **C3**: ABGR/lt/tr/b, 8369, 8370. ABGR/lt/trb/w, 8361, 8364. ACMA/lt/trc/w, 7333. ACMA/stn/trc/w, 7345. COSP/sn/tr/w, 7346. PSME/lt/tr/b, 7327, 7330, 7331, 8362. **C4**: ABGR/dt/tr/b, 8427. PSME/lt/tr/b, 8416, 8423, 8425. **C6**: PSME/lt/tr/b, 7221. QUGA/dt/br/b, 7218. **C8a**: PSME/lt/tr/b, 7115. **C8b**: COSP/fp/trb/w, 8040. BRSP/log/re/w, 6002. FRLA/stn/tr/w, 8042. PSME/lt/tr/b, 6004. **D1a**: ABPR/dt/tr/b, 7015A, 7018, 7017. ABPR/dt/trbc/b, 7007A. ABPR/dt/trbc/w, 7007B. ABPR/lt/trbc/w, 7008A. ABPR/sn/tr/b, 7024C. ABPR/sn/tr/w, 7002, 7004, 7013B, 7019, 7022. TSHE/lt/tr/b, 7010. **D1b**: PSME/sn/tr/w, 6001. **D2**: COSP/sn/tr/w, 6129, 6144. **D3b**: ABSP/lt/tr/b, 6044. COSP/sn/tr/w, 6041. **D3c**: COSP/sn/trc/w, 6055. **D4**: ABSP/sn/tr/w, 8675. TSHE/lt/tr/b, 8673. TSHE/sn/tr/w, 8676. **D5**: PSME/lt/tr/b, 7047B. TSHE/lt/tr/b, 7045. **D6b**: PSME/lt/tr/b, 7037. **D7**: COSP/sn/tr/w, 6102. **E1**: COSP/sn/tr/w, 6059. **E2**: COSP/sn/tr/w, 6097. **E3a**: ABSP/sn/tr/w, 8512. COSP/sn/tr/w, 8523. **E3b**: PSME/sn/tr/w, 8532. **E6**: COSP/sn/tr/w, 8312. PIPO/sn/trb/w, 8318. PIPO/sn/tr/w, 8313, 8315. **F2**: ABSP/sn/trb/w, 8648. ABSP/stn/trb/w, 8644. **F4**: ABSP/lt/trc/w, 8553. TSME/sn/tr/w, 8556. **F6b**: ABGR/lt/br/b, 8613. **G1b**: CHLA/lt/tr/b, 8072B. **G2**: CHLA/lt/tr/b, 7089, 7092–7097. LIDE/sn/tr/b, 7086. PSME/dt/trc/w, 7087, 7088. PSME/lt/tr/b, 7085. **G4b**: PSME/sn/tr/w, 7071. QUCR/sn/trbc/w, 7074. **G4c**: PSME/stc/tr/b, 7080. PSME/stn/tr/w, 7082.

Chaenotheca chlorella (Ach.) Müll. Arg. — Infrequent over wood and bark mainly at lower elevations. Most collections have been made from mature mixed forests in the Willamette Valley (Rikkinen 1998, Peterson & Rikkinen 1999). Total 12 specimens.

B4: THPL/lt/tr/b, 8285. THPL/lt/tr/w, 8286. **C1**: COSP/sn/tr/w, 8014. **C6**: QUGA/dt/br/b, 7218. QUGA/lt/br/b, 7219. QUGA/sn/tr/w, 7195, 7223. **C8a**: QUGA/dt/trbc/w, 7124. **C8b**: QUGA/sn/trc/w, 8037. **E3a**: TSME/dt/trbc/w, 8518. **E6**: PIPO/sn/tr/w, 8315. PIPO/sn/trb/w, 8318.

Chaenotheca chrysocephala (Ach.) Th. Fr. — Frequent over bark and wood of conifers in montane forests and in the foothills of the Willamette Valley. Prefers semi-open forests at relatively low elevations and is most abundant on conifer trunks in mixed forests and in edge habitats, also in relatively young stands. More or less absent from conifer trunks in closed low-elevation rainforests. Frequently infected by *Chaenothecopsis consociata*, but the infections are not nearly as extensive as those commonly seen in northern Europe. Total 98 specimens.

A3a: PISI/lt/tr/b, 8349. PISI/sn/tr/b, 8462. PSME/lt/tr/b, 8463, 8465. PISI/lt/tr/b, 8172, 8173, 8175. PSME/lt/tr/b, 8168, 8174. **A6b**: PISI/lt/trb/b, 8180. PISI/lt/tr/b, 8186. **A7a**: PSME/lt/trbc/b, 8256. **A7b**: PSME/lt/tr/b, 8262. TSHE/lt/tr/b, 8258, 8265. **B1**: PSME/lt/tr/b, 8207, 8222. **B2a**: PSME/lt/tr/b, 7161, 7165. THPL/lt/tr/b, 7160. **B2b**: PSME/dt/trbc/w, 8502. **B3**: COSP/stc/tr/w, 7178. **B4**: PSME/lt/tr/b, 8306. THPL/lt/tr/b, 8287, 8297. **B5**: PSME/lt/tr/b, 8111, 8113, 8121, 8124, 8131. **B7**: PSME/lt/tr/b, 8398, 8400, 8409. **B9**: PSME/dt/tr/b, 8473. PSME/lt/tr/b, 8470–8472, 8474, 8475. PSME/sn/tr/b, 8479. THPL/lt/tr/b, 8487. **B10a**: THPL/lt/tr/b, 6106, 6111. **C1**: ABGR/lt/tr/b, 8023, 8026. PSME/dt/tr/b, 8002. PSME/lt/tr/b, 8005, 8018–8020, 8022. **C2**: ABSP/lt/tr/b, 7238, 7239, 7241. PSME/lt/tr/b, 7230, 7233, 7336, 7261, 7282. **C3**: ALRU/stn/trc/w, 7329. PSME/lt/tr/b, 8362. **C4**: ABGR/dt/tr/b, 8426, 8427. PSME/lt/tr/b, 8415, 8416, 8423–8425. **C6**: PSME/lt/tr/b, 7192, 7221, 7222, 7224–7226, 7288. **C7b**: ABSP/lt/tr/b, 7248. **C8a**: ABSP/lt/trb/b, 7120. PSME/lt/tr/b, 7115, 7117. PSME/lt/trbc/b, 7123. **C8b**: COSP/fp/trb/w, 8035, 8040. PSME/lt/tr/b, 6004. **D1a**: ABPR/dt/tr/b, 7006, 7017. ABPR/sn/trbc/w, 7011. ABPR/sn/tr/b, 7024C. **D2**: ABSP/lt/tr/b, 6132, 6134, 6137A. ABSP/lt/trb/b, 6140. **D3a**: PSME/lt/tr/b, 6030. **D5**: TSHE/lt/tr/b, 7045. **E3a**: PSME/lt/tr/b, 8515. **E3b**: PSME/lt/tr/b, 8540. **E6**: PIPO/sn/trb/w, 8318. **G1b**: CHLA/lt/tr/b, 8072B. **G4c**: PSME/stc/tr/b, 7080.

Chaenotheca cinerea (Pers.) Tibell — Rare over bark of old trees in humid, semi-open forests at high elevations (Peterson & Rikkinen 1999). Total three specimens.

E3b: POTR/lt/tr/b, 8543. **F2**: CHNO/lt/tr/b, 8646, 8650.

Chaenotheca ferruginea (Turner *ex* Sm.) Mig. — Frequent over bark and wood of conifers in montane forests and in the foothills of the Willamette Valley. Prefers semi-open forests and edge habitats, but also grows on conifer trunks in rainforests. Most specimens from humid low-elevation forests have poorly developed or immersed thalli. Total 47 specimens.

A3a: PSME/lt/tr/b, 8336. PSME/lt/tr/b, 8337, 8338. **A3b**: PISI/lt/trbc/b, 8461. **A5a**: PSME/sn/tr/w, 8155, 8156. **B1**: PSME/lt/tr/b, 8207. **B2a**: PSME/lt/tr/b, 7165. **B4**: THPL/lt/tr/b, 8287. **B5**: PSME/sn/tr/w, 8108, 8117, 8126. **B6**: PSME/sn/tr/w, 8379, 8380, 8387. **B9**: PSME/lt/tr/b, 8474, 8475. THPL/lt/tr/b, 8484, 8487. TSHE/lt/tr/b, 8495. **B10a**: THPL/lt/tr/b, 6108. **C1**: PSME/dt/tr/b, 8002. **C2**: PSME/lt/tr/b, 7282. **C3**: PSME/lt/tr/b, 8362. **C4**: PSME/lt/tr/b, 8415, 8416. **C6**: PSME/lt/tr/b, 7221, 7224–7226, 7288. **C8b**: COSP/fp/tr/w, 6007. COSP/fp/trb/w, 8035. **D2**: PSME/lt/trb/b, 6141. **D3a**: COSP/sn/tr/w, 6039. **D4**: PSME/lt/tr/b, 8665. TSHE/lt/trbc/w, 8656. **D6b**: PSME/sn/tr/w, 7034. **E3a**: PSME/lt/tr/b, 8520. TSME/lt/trc/b, 8525. **E3b**: PSME/lt/tr/b, 8540. **F6b**: ABGR/lt/tr/b, 8615. **F6c**: ABSP/lt/tr/b, 8626, 8627. PIMO/lt/tr/b, 8629. PIMO/lt/tr/b, 8631. **G4c**: ABCO/sn/tr/b, 2021.

Chaenotheca furfuracea (L.) Tibell — Frequent over bark, wood, detritus and soil in sheltered microhabitats, like in deep crevices under overhanging trees, cliffs and cut earth banks. Total 89 specimens.

A1: PISI/lt/trbc/w, 8439. PISI/lt/trc/b, 8441. PISI/stn/trb/w, 8437. TSHE/lt/tr/b, 8449. **A3a**: PISI/lt/tr/b, 8349. PSME/lt/tr/b, 8337, 8338. **A3b**: PISI/lt/trb/b, 8452. **A4**: TSHE/lt/tr/b, 7304. **A5a**: PISI/stn/tr/w, 8152. PSME/log/trc/b, 8154. **A6a**: PISI/lt/tr/b, 8166. **A6b**: PISI/lt/trbc/b, 8188. **A7a**: ACMA/lt/trbc/b, 8253. PSME/lt/trbc/b, 8256. PSME/stc/trb/w, 8250. **A7b**: PSME/lt/trbc/b, 8259, 8261, 8269. PSME/sn/trb/w, 8267. TSHE/lt/tr/b, 8258. **A8**: PISI/lt/trbc/b, 8099. **A9**: SESE/log/trb/b, 8225. **A11**: ALRU/log/trbc/b, 2068. ALRU/lt/trbc/b, 2067. **B1**: PSME/lt/trb/b, 8205. PSME/lt/tr/b, 8205–8207. ROCK/-/-/rock, 8203, 8204, 8208, 8221. **B2a**: PSME/lt/tr/b, 7165. **B3**: PSME/-/-/detr, 7177, 7180. ROCK/-/-/rock, 7179. **B4**: PSME/lt/tr/b, 8304, 8306. ROCK/-/-/detr, 8302. THPL/lt/tr/b, 8285, 8301, 8305, 8308. THPL/lt/tr/w, 8286. TSHE/lt/trbc/w, 8309. **B5**: PSME/sn/trbc/detr, 8112. **B6**: PSME/lt/tr/b, 8385. **B7**: PSME/lt/tr/b, 8397, 8400. **B8**: PSME/stn/trbc/w, 6017. **B9**: PSME/lt/trb/b, 8476, 8480. PSME/lt/tr/b, 8486. THPL/lt/tr/b, 8477. TSHE/lt/tr/b, 8495. **B10a**: COSP/log/ro/b, 6113. **C1**: PSME/lt/tr/b, 8018, 8019. **C2**: PSME/log/ro/b, 7283. PSME/lt/re/b, 7259. **C3**: ABGR/lt/tr/b, 8369. ABSP/log/ro/b, 7332. ABSP/lt/tr/b, 7325, 7326. PSME/log/ro/b, 7347. TABE/lt/tr/b, 7341. **C4**: ABGR/lt/trb/b, 8414. **C6**: PSME/stc/trb/w, 7190. **C8a**: PSME/log/trbc/w, 7121. PSME/lt/trb/detr, 7119. **C8b**: BRSP/log/re/w, 6002. **D1a**: ABPR/dt/tr/b, 7006. ABPR/sn/trbc/w, 7011, 7024A. **D2**: ABSP/lt/trbc/b, 6137B. **D3a**: PSME/lt/trbc/b, 6035. **E1**: THPL/lt/tr/b, 6065. **E4**: ROCK/-/-/rock, 8559. **E6**: ROCK/-/-/detr, 8326. **F2**: TSME/lt/trbc/b, 8653. TSME/lt/tr/b, 8655. **F6b**: TSME/lt/trbc/w, 8614. **F6c**: ROCK/-/-/detr, 8624B. **G2**: CHLA/lt/trbc/detr, 7090. **G4a**: PSME/lt/re/b, 7068. **G4c**: PSME/stc/tr/b, 7080. ROCK/-/-/rock, 7075. **G5**: SEGI/log/trb/b, 2051A.

Chaenotheca gracilenta (Ach.) Mattson & Middelborg — Infrequent over wood and bark in humid old-growth forests. The most abundant populations have been seen on basal trunks of aged, damaged *Acer macrophyllum* in riparian forests (Peterson & Rikkinen 1999). Total 17 specimens.

A3a: ACMA/lt/tr/b, 8348. **A5a**: PISI/lt/trbc/w, 8138. PISI/stc/trbc/w, 8143. **A6a**: PISI/lt/tr/b, 8166, 8172, 8173, 8175. **A7a**: ACMA/lt/trbc/b, 8249. **B1**: ACMA/lt/tr/b, 8209, 8211. ACMA/sn/tr/w, 8210, 8213. ROCK/-/-/detr, 8216. **B8**: ACMA/lt/tr/b, 6015. **D1a**: ABPR/dt/trbc/w, 7015B. ABPR/sn/trbc/w, 7013A. **D6b**: PSME/stn/tr/w, 7036.

Chaenotheca gracillima (Vain.) Tibell — Frequent over wood and bark in humid, sheltered microhabitats mainly at lower elevations. Most common on relatively soft lignum and decomposing bark of conifers in mature riparian forests in the foothills of the Willamette Valley. Total 25 specimens.

A2b: PISI/stn/tr/w, 7136. **A9**: SESE/lt/tr/b, 8224. **B2a**: PSME/lt/tr/b, 7161, 7165. **B4**: THPL/lt/tr/b, 8301. **B5**: PSME/stn/tr/w, 8130. **B6**: PSME/sn/tr/w, 8371. **B7**: PSME/sn/tr/w, 8403. **C1**: ACMA/sn/tr/w, 8011. COSP/stn/tr/w, 8012. COSP/stn/trbc/w, 8009. PSME/sn/tr/b, 8017. **C2**: PSME/sn/trbc/w, 7335. **C3**: ABSP/lt/tr/b, 7326. **C6**: PSME/lt/tr/b, 7221. PSME/stc/trb/w, 7190. **C8a**: PSME/log/trbc/w, 7121. **D1a**: ABPR/dt/trbc/w, 7015B. ABPR/log/trc/w, 7014. ABPR/sn/tr/w, 7013B, 7024B. **D3a**: COSP/sn/tr/w, 6028. **D5**: PSME/sn/tr/w, 7050A. **E6**: PIPO/sn/tr/w, 8314. **G2**: PSME/sn/trbc/w, 7091.

Chaenotheca hispidula (Ach.) Zahlbr. — Rare over wood and bark of deciduous trees in the Willamette Valley (Rikkinen 1998, Peterson & Rikkinen 1999). Total six specimens.

C7a: ACMA/sn/trbc/w, 7207. ACMA/lt/trbc/w, 7215. **C8a**: ABSP/lt/trb/b, 7120. **C8b**: FRLA/lt/trb/w, 8044. FRLA/lt/trb/b, 8045. QUGA/sn/trc/w, 8037.

Chaenotheca hygrophila Tibell — Frequent over wood and bark in mature rainforests in the *Tsuga heterophylla* Zone. The variation of this species is not adequately understood and some specimens presently included in *Chaenotheca brunneola s. lato* may actually belong here. Typical specimens of *C. hygrophila* have robust ascomata, a well developed excipulum and non-catenulate asci. Such specimens are common on large conifer snags in very humid forests, often growing together with *Calicium lenticulare*. Total 47 specimens.

A6a: COSP/stn/tr/w, 8169. **B2a**: THPL/lt/trbc/b, 7162. **B2c**: PSME/sn/tr/w, 83469. **B4**: PSME/lt/tr/w, 8292–8296, 8300, 8303. THPL/lt/tr/b, 8288, 8301, 8305. THPL/sn/tr/w, 8298. **B5**: PSME/lt/tr/b, 8122. PSME/sn/tr/b, 8133, 8134. PSME/sn/tr/w, 8107–8110, 8114, 8117, 8119, 8120, 8126–8129, 8135. **B6**: PSME/sn/tr/w, 8372, 8374, 8380, 8381, 8384, 8391. **B7**: PSME/lt/tr/b, 8404. PSME/sn/tr/w, 8278–8280, 8399, 8401–8403, 8405, 8406. **C1**: PSME/sn/tr/w, 8021.

Chaenotheca laevigata Nádv. — Rare over wood and bark in mature, semi-open forests of the Willamette Valley and at higher elevations. Absent from low-elevation rainforests. Total eight specimens.

C1: ABGR/lt/tr/b, 8023. **C4**: ABGR/dt/tr/b, 8417. **C5**: QUGA/sn/tr/w, 7174. **C7a**: ACMA/lt/tr/w, 7167. **D1a**: ABPR/sn/tr/w, 7024B. **E2**: COSP/sn/tr/w, 6078. **G2**: CHLA/lt/tr/b, 7092, 7093.

Chaenotheca cf. *nitidula* Tibell — Locally frequent over wood in humid forests at low and middle elevations in the Cascades and especially in the foothills of the Willamette Valley. Characterized by its immersed thallus, relatively tall (1–3 mm high) ascomata with thin and flexuous stalks, a well-developed cup-like excipulum of mixed hyphae, catenulate asci, and brown, relatively large ascospores (4–6 μm). The spores are variable in size, but develop a rough ornamentation when mature. The stalk is dark reddish brown at the base and pale yellowish brown in the upper parts. The photobiont cells are 5–10 μm long, irregular and occur in tightly packed colonies. The specimens correspond rather well with the specimens recently described from eastern North America (Tibell & Koffman 2002) In the Pacific Northwest the species is almost invariably associated with a structurally complex synnematous fungus, which usually grows on the same substrate, but sometimes also on decomposing ascomata of the *Chaenotheca* species (Rikkinen, unpubl.). Total 37 specimens.

B2b: TSHE/lt/trc/w, 8504. **C1**: ALRU/dt/tr/w, 8001. ALRU/sn/tr/w, 8004. COSP/sn/tr/w, 8013. **C3**: ABGR/lt/trb/w, 8358. ACMA/stn/trc/w, 7345. ACMA/dt/trbc/w, 7343. ALRU/stn/trc/w, 7329. COSP/sn/tr/w, 7346. TABE/sn/tr/w, 7337, 7340. **C4**: ACMA/sn/tr/w, 8421. FRLA/dt/tr/b, 8430. **C6**: QUGA/log/trbc/w, 7197. **C7a**: ACMA/sn/trbc/w, 7211. **C8b**: FRLA/stn/tr/w, 8042. QUGA/lt/trbc/w, 8051. **D2**: COSP/sn/tr/w, 6128. **D3b**: ABSP/sn/tr/w, 6051C. **D4**: ABSP/sn/tr/w, 8669. TSHE/lt/trbc/w, 8660, 8677. TSHE/lt/trbc/b, 8661. **D6a**: COSP/stc/trb/w, 7030. **D6b**: PSME/stn/tr/w, 7036. **E3a**: TSME/dt/trbc/w, 8518. **E3b**: ABSP/dt/trc/w, 8530. **E6**: ABSP/sn/tr/w, 8322. PIPO/sn/tr/w, 8315. PSME/stn/tr/w, 8321. **F2**: ABPR/sn/tr/w, 8641, 8640. CHNO/sn/trb/w, 8643. **F4**: ABSP/lt/trc/w, 8553. COSP/sn/tr/w, 8551. **F6b**: TSME/sn/trbc/w, 8620. **G6a**: ABCO/sn/tr/w, 2009.

Chaenotheca olivaceorufa Vain. — Locally frequent, but very easily overlooked over wood and bark in basal crevices of old hardwoods and snags at low elevations. Largely restricted to coastal forests and the Willamette Valley (Rikkinen 1998). Total 22 specimens.

A3a: PISI/lt/trbc/w, 8342. **A3b**: PISI/sn/tr/b, 8462. TSHE/lt/trc/w, 8456. **A5a**: PISI/lt/trbc/w, 8138. PISI/lt/trbc/b, 8144, 8149. TSHE/lt/trbc/b, 8148. TSHE/stc/trbc/b, 8153. **A6b**: PISI/lt/trb/b, 8182. PISI/lt/trbc/b, 8184. **A7a**: PSME/lt/trbc/b, 8256. **A8**: PISI/lt/trbc/b, 8099. **A10a**: SESE/lt/trbc/w, 8245. **A14**: SESE/log/trbc/w, 2066. **B1**: ACMA/lt/tr/b, 8209. PSME/lt/tr/b, 8207. **C1**: COSP/sn/tr/w, 8014. **C3**: TABE/lt/tr/b, 7341. TABE/lt/trbc/w, 8367. **C7a**: ACMA/sn/trbc/w, 7207. ACMA/lt/trbc/w, 7215. **C8a**: QUGA/dt/trbc/w, 7124.

Chaenotheca phaeocephala (Turner.) Th. Fr. — Frequent over bark and wood in montane forests and in the Willamette Valley. Absent from low-elevation rainforests. Total 22 specimens.

C1: ABGR/lt/tr/b, 8026. PSME/lt/tr/b, 8005, 8019, 8020. PSME/dt/tr/b, 8002. **C3**: ABGR/lt/tr/b, 8369. **C4**: ABGR/dt/tr/b, 8427. **C5**: QUGA/lt/trc/w, 7169. **C6**: QUGA/dt/br/b, 7218. **C8a**: PSME/lt/tr/b, 7115, 7116. **D1a**: ABPR/sn/tr/w, 7013B. **D2**: PSME/lt/trb/b, 6143. **D3a**: PSME/stn/tr/w, 6024. **D5**: TSHE/lt/tr/b, 7045. **D6a**: PSME/log/tr/w, 7026. **E2**: PSME/dt/tr/b, 6093. **E6**: PIPO/sn/tr/w, 8313. **G4a**: PSME/lt/tr/b, 7065, 7069. **G5**: ABCO/lt/tr/b, 2052, 2053.

Chaenotheca stemonea (Ach.) Müll. Arg. — Frequent over bark and wood in humid forests at lower elevations, especially in coastal forests (Rikkinen 1998, Peterson & Rikkinen 1999). Total 42 specimens.

A1: PISI/lt/trc/b, 8434. PISI/lt/trc/b, 8433. PISI/sn/tr/w, 8448. **A2c**: PISI/log/trbc/w, 7156. **A3a**: PISI/lt/tr/b, 8349, 8335. PISI/lt/trb/b, 8334. **A3b**: PISI/lt/trb/b, 8452–8454, 8457. **A4**: PISI/lt/tr/b, 7307. TSHE/lt/tr/b, 7308. **A5a**: PISI/lt/trbc/b, 8149, 8144. PISI/lt/trbc/w, 8138. TSHE/lt/trbc/b, 8148. TSHE/stc/trbc/b, 8153. **A6a**: PISI/lt/tr/b, 8172, 8173. PISI/lt/trbc/b, 8163, 8164. PSME/lt/tr/b, 8174. **A6b**: PISI/lt/trb/b, 8180, 8182. PISI/lt/trbc/b, 8183, 8184, 8188. PISI/sn/trb/w, 8185. **A7b**: PSME/lt/trbc/b, 8259. **B1**: THPL/sn/tr/w, 8214. **B3**: COSP/stc/tr/w, 7178. **B4**: PSME/lt/tr/b, 8304. **B7**:

PSME/lt/tr/b, 8400. **B10b**: PSME/stn/tr/w, 6118. **C1**: ABGR/stn/trb/w, 8027. COSP/sn/tr/w, 8013. COSP/stn/trbc/w, 8015. **C3**: PSME/lt/tr/b, 7335. **C8a**: QUGA/dt/trbc/w, 7124. **D4**: TSHE/lt/trbc/w, 8662. **E2**: COSP/sn/tr/w, 6078.

Chaenotheca subroscida (Eitner) Zahlbr. — Frequent over conifer bark and wood in humid montane and subalpine forests, especially east of the Cascade Crest. Absent from the *Picea sitchensis* and *Tsuga heterophylla* Zones. Total 18 specimens.

D3b: ABSP/lt/tr/b, 6044. **D5**: PSME/lt/tr/b, 7047B. **E1**: PSME/lt/tr/b, 6068. THPL/lt/tr/b, 6061, 6071. **E3a**: PIEN/lt/trbc/b, 8521. PSME/lt/tr/b, 8520. **E3b**: ABSP/dt/trc/w, 8530. **E4**: PSME/lt/tr/b, 8569. **F2**: ABSP/sn/trb/b, 8647B. CHNO/lt/tr/b, 8646. **F6b**: ABGR/lt/br/b, 8613. ABGR/lt/tr/b, 8615. PSME/dt/br/b, 8611. **F6c**: ABSP/lt/tr/b, 8627. PIMO/lt/tr/b, 8629, 8631. TSME/dt/trbc/w, 8624C.

Chaenotheca trichialis (Ach.) Th. Fr. — Frequent over conifer bark and lignum at all elevations. Most common in montane forests and in the Willamette Valley, where most specimens have a well developed squamulose or roughly granulose thallus. Specimens from low-elevation rainforests and other humid habitats tend to have a poorly developed or completely immersed thallus (Tibell 2002). Total 84 specimens.

A3a: PISI/lt/tr/b, 8349, 8346. PISI/lt/trb/b, 8334. **A3b**: PISI/lt/trbc/b, 8461. PISI/sn/tr/b, 8462. PSME/lt/tr/b, 8463. **A5a**: PISI/lt/trbc/w, 8138. PISI/sn/trbc/w, 8137. **A7a**: PSME/lt/trbc/b, 8256. **A8**: PSME/lt/tr/b, 8094. **A10a**: SESE/lt/trc/w, 8247. **A10b**: PSME/lt/tr/b, 7107. SESE/lt/tr/b, 7106. **A14**: SESE/log/trbc/w, 2066. **B2a**: PSME/lt/tr/b, 7165. **B4**: PSME/lt/tr/b, 8304. **B7**: PSME/lt/tr/b, 8277, 8397, 8400, 8408, 8410. **B9**: PSME/lt/tr/b, 8478, 8472, 8475. **C1**: ABGR/stn/trb/w, 8027. COSP/sn/tr/w, 8013, 8014. COSP/stn/trbc/w, 8015. PSME/lt/tr/b, 8018–8020. PSME/lt/trb/b, 8016. **C2**: PSME/lt/tr/b, 7282, 7233. **C4**: FRLA/lt/trbc/w, 8413. **C5**: QUGA/sn/tr/w, 7174. **C6**: PSME/lt/tr/b, 7288, 7222. QUGA/sn/tr/w, 7223. QUGA/stn/tr/w, 7287. **C8a**: PSME/lt/tr/b, 7118. **D1a**: ABPR/sn/tr/w, 7024B. ABPR/dt/trbc/w, 7021. **D2**: ABSP/lt/tr/b, 6137A. PSME/lt/tr/b, 6136, 6135. **D3a**: COSP/sn/tr/w, 6039. PSME/lt/trbc/b, 6035. PSME/lt/tr/b, 6030. **D3b**: ABSP/sn/tr/b, 6051B. **D4**: TSHE/lt/trbc/w, 8656. **D5**: PSME/lt/tr/b, 7047B. **E1**: THPL/lt/tr/b, 6061. **E2**: COSP/sn/tr/w, 6078, 6088. PSME/dt/tr/b, 6093. **E3a**: TSME/dt/trbc/w, 8518. **E3b**: ABSP/dt/trc/w, 8530. **E6**: PIPO/sn/tr/w, 8313, 8314, 8327, 8329. PSME/lt/tr/b, 8331. **F2**: ABSP/sn/tr/w, 8654, 8651. ABSP/stn/trb/w, 8645. CHNO/lt/tr/b, 8650. TSME/lt/tr/b, 8655. **F6b**: TSME/lt/tr/b, 8619. **F6c**: PIMO/lt/tr/b, 8631. PIMO/lt/trbc/b, 8632, 8628. ROCK/-/-/detr, 8624B. TSME/lt/trbc/w, 8635. **G1b**: CADE/lt/trbc/w, 8062. CHLA/lt/tr/b, 8072B. CHLA/lt/tr/w, 8072A. PSME/lt/tr/b, 8070. **G4a**: PSME/lt/tr/b, 7067, 7065. PSME/sn/tr/b, 7066. **G4c**: PSME/lt/tr/b, 7083, 7078. **G5**: CADE/dt/tr/b, 2059.

Chaenotheca xyloxena Nádv. — Infrequent over lignum at all elevations. Total 16 specimens.

A3b: PISI/sn/tr/b, 8466. **A4**: PSME/lt/tr/b, 7305. TSHE/lt/tr/b, 7308. **A7a**: PSME/sn/tr/w, 8255, 8254. **B2b**: PSME/lt/trbc/w, 7175. **B5**: PSME/sn/tr/w, 8117. **C3**: ALRU/stn/trc/w, 7329. **D2**: COSP/sn/tr/w, 6146. **E6**: PIPO/sn/tr/w, 8329, 8315. PIPO/sn/trb/w, 8318. **F5**: ABLA/stc/trb/w, 8594. **G3a**: CADE/sn/trb/w, 7055. **G4b**: QUCR/sn/trbc/w, 7074. **G6c**: PIPO/lt/trbc/w, 2025.

Sclerophora cf. *farinacea* (Chevall.) Chevall. — Rare over bark and wood of old hardwoods in the Willamette Valley, usually together with *Sclerophora peronella*. Characterized by its relatively large (1–1.5 mm high) ascomata with pale to reddish brown stalks, distinctive pale yellowish collar, K+ violet mazaedium, and relatively large (5–7 μm), roughly ornamented spores (Rikkinen 1998). Total eight specimens.

C6: QUGA/dt/tr/b, 7220. FRLA/lt/tr/b, 8043. QUGA/lt/tr/b, 6013, 8029, 8032, 8039. QUGA/lt/tr/w, 8034. TODI/dt/tr/b, 8038.

Sclerophora peronella (Ach.) Tibell — Infrequent over wood and bark at lower elevations. The most abundant populations have been seen on the basal trunks of aged *Quercus garrayana* in the Willamette Valley (Rikkinen 1998). Total 14 specimens.

B3: ACMA/lt/trc/w, 7324. **B4**: THPL/lt/tr/w, 8286. **C3**: ABGR/lt/trb/w, 8358. ABGR/lt/tr/b, 8370. FRLA/lt/tr/b, 8366. PSME/lt/tr/b, 7327. **C5**: QUGA/sn/tr/w, 7174. **C6**: QUGA/lt/tr/b, 7191. **C8b**: QUGA/lt/tr/b, 6010, 8041. QUGA/lt/tr/w, 8034. **D1a**: ABPR/lt/trc/w, 7008B. **E2**: COSP/sn/tr/w, 6082, 6086.

Mycocaliciaceae

Chaenothecopsis "*aeruginosa*" Goward, *ined.* — Rare (probably overlooked) over bark of conifers in humid old-growth forests west of the Cascade Crest, often intermixed with *Chaenothecopsis nana*. Characterized by its relatively large ascomata with aeruginose capitula, narrow stalks with mixed hyphae and a pale excipulum. The

whitish color of the excipulum is due to an amorphous surface layer with relatively large (3–10 μm) crystals. The pale spores are 1-septate, broadly ellipsoidal to subfusiform and relatively large (7–11 μm long). The spore wall is laterally thickened and the translucent septum is very easily overlooked. Total four specimens.

B9: PSME/lt/tr/b, 8474, 8475. **D4**: PSME/lt/tr/b, 8665. TSHE/lt/tr/b, 8672.

Chaenothecopsis cf. *amurensis* Titov — Rare, found twice growing over an undescribed *Bactrospora* species (with *Trentepohlia*) on *Abies grandis* trunks in a semi-open, aged riparian forest in the foothills of the Willamette Valley. Characterized by its epruinose, well-stalked ascomata with lenticular capitula and periclinally arranged hyphae in the stalk and excipulum. The asci are cylindrical or narrowly clavate, 25–35 μm long, and have irregularly, often biseriately arranged spores. The ascus apex is distinctly thickened and penetrated by a fine canal. The non-septate, smooth and pale spores are narrowly ellipsoidal to allantoid (5–6.5 μm long), with pointed ends. This species should also be compared with *Chaenothecopsis australis*, *C. trassii*, *C. weiana* and other similar taxa when more material becomes available (Tibell 1998, Titov 2001). Total two specimens.

C1: ABGR/lt/tr/b, 8023, 8026.

Chaenothecopsis asperopoda Titov — Rare over resin and resin impregnated bark of *Tsuga heterophylla* in riparian low-elevation forests (Selva & Tibell 1999). Total two specimens.

A3a: TSHE/lt/trc/re, 8345. **B9**: TSHE/lt/trc/re, 8491.

Chaenothecopsis consociata (Nádv.) A.F.W. Schmidt — Frequent over *Chaenotheca chrysocephala* on bark of conifers at lower elevations (Peterson & Rikkinen 1999). Total 19 specimens.

A7b: PSME/lt/tr/b, 8262. TSHE/lt/tr/b, 8258. **B2a**: PSME/lt/tr/b, 7161. **B5**: PSME/lt/tr/b, 8113, 8131. **B9**: PSME/dt/tr/b, 8473. PSME/lt/tr/b, 8471, 8472, 8474, 8475. **C1**: ABGR/lt/tr/b, 8023. **C2**: ABSP/lt/tr/b, 7239, 7241. PSME/lt/tr/b, 7230, 7233, 7236, 7361. **C3**: PSME/lt/tr/b, 8362. **C4**: PSME/lt/tr/b, 8415.

Chaenothecopsis debilis (Sm.) Tibell — Frequent over hard lignum in montane forests and in the Willamette Valley (Rikkinen 1998, Peterson & Rikkinen 1999). Total 25 specimens.

B4: THPL/lt/tr/w, 8286. **C5**: QUGA/sn/tr/w, 7174. **C6**: QUGA/sn/tr/w, 7195, 7223, 7227. QUGA/stn/tr/w, 7289. **C7a**: ACMA/sn/trbc/w, 7207. **C8a**: QUGA/sn/tr/w, 7111. QUGA/sn/trbc/w, 7122. **C8b**: ACMA/sn/tr/w, 8047. FRLA/lt/trb/w, 8044. **D4**: TSHE/lt/trbc/w, 8656. **E3b**: ABSP/dt/trc/w, 8535. **E6**: PIPO/sn/tr/w, 8315. **F4**: COSP/sn/tr/w, 8551. **F6a**: TSME/lt/trc/w, 8605. **F6b**: TSME/sn/trbc/w, 8620. **F6c**: TSME/lt/trbc/w, 8635. **G1b**: CADE/lt/tr/b, 8061. CADE/lt/trbc/w, 8062. CHLA/lt/tr/w, 8072A. **G4b**: ARME/lt/trbc/w, 7072. **G11**: CELE/lt/trb/w, 2038. **G12**: PILO/lt/trc/w, 2034, 2035.

Chaenothecopsis epithallina Tibell — Rather frequent over *Chaenotheca trichialis* on bark and wood of conifers in humid montane forests. Not common in closed low-elevation rainforests. Total 15 specimens.

B7: PSME/lt/tr/b, 8277, 8397, 8400, 8408, 8410. **B9**: PSME/lt/tr/b, 8475, 8478. **C4**: FRLA/lt/trbc/w, 8413. **D1a**: ABPR/dt/trbc/w, 7021. **D3a**: COSP/sn/tr/w, 6039. **D5**: PSME/lt/tr/b, 7047B. **E2**: COSP/sn/tr/w, 6078. **F2**: TSME/lt/tr/b, 8655. **F6c**: TSME/lt/trbc/w, 8635. **G4c**: PSME/lt/tr/b, 7083.

Chaenothecopsis haematopus Tibell — Rare over bark and wood of conifers at lower elevations. Total three specimens.

B9: THPL/lt/tr/b, 8487. **G1b**: PSME/sn/tr/w, 8071A. COSP/lt/tr/b, 8074.

Chaenothecopsis montana Rikkinen — Frequent over resin and resin impregnated wood of scarred *Abies* and *Tsuga* trunks in mature montane forests. Also on beaver damaged *Abies grandis* in low elevation riparian forests (Rikkinen 2003b). Total 21 specimens.

B2b: TSHE/lt/trbc/re, 8499. **C3**: ABGR/lt/trb/re, 8363. **C4**: ABGR/dt/tr/re, 8417. **D4**: ABSP/lt/trbc/re, 8670, 8671, 8679. **E3a**: ABLA/lt/trc/re, 8509, 8526, 8517. ABSP/dt/trc/re, 8516. TSME/dt/trc/re, 8508. TSME/dt/trbc/re, 8518. TSME/lt/trc/re, 8525. **E3b**: ABSP/dt/trc/re, 8530. ABSP/lt/trc/re, 8531, 8541. **E4**: ABSP/lt/trbc/re, 8576. **E5**: ABGR/lt/tr/re, 8589. **F2**: ABPR/lt/trc/re, 8638. **F4**: ABSP/lt/trc/re, 8548. **G3a**: ABSP/lt/trbc/re, 7052.

Chaenothecopsis nana Tibell — Frequent over conifer bark at higher elevations, especially

in montane forests. Infrequent in low-elevation rainforests and apparently absent from the *Picea sitchensis* Zone. Often associated with ancient resin flows and frequently growing on dry, weathered resin (Peterson & Rikkinen 1999). Total 57 specimens.

B1: PSME/lt/tr/b, 8222. **B2a**: PSME/lt/tr/b, 7161. **B9**: TSHE/lt/tr/b, 8495. **C1**: PSME/dt/tr/b, 8002. PSME/lt/tr/b, 8020. **C3**: PSME/lt/tr/b, 7335. **C8b**: QUGA/lt/tr/b, 6010. **D2**: PSME/lt/tr/b, 6136. PSME/lt/trb/b, 6141, 6143. **D3a**: PSME/lt/tr/b, 6030, 6037. **D4**: PSME/lt/tr/b, 8665. TSHE/lt/tr/b, 8672. **D5**: PSME/lt/tr/b, 7047B. TSHE/lt/tr/b, 7045. **D6b**: PSME/lt/tr/b, 7037. PSME/stn/trb/b, 7031C. **E1**: PSME/lt/tr/b, 6068. THPL/lt/tr/b, 6061, 6065, 6071. **E3a**: PIEN/lt/trbc/b, 8521. PSME/lt/tr/b, 8520. **E3b**: PSME/lt/tr/b, 8540. **E4**: LAOC/dt/tr/b, 8577. PSME/lt/tr/b, 8569, 8573. **E6**: ABSP/dt/trb/b, 8325. PSME/lt/tr/b, 8331. **F2**: ABSP/sn/trb/b, 8647B. **F6a**: TSME/lt/tr/b, 8607. **F6b**: ABGR/lt/tr/b, 8615. PSME/dt/br/b, 8611. TSME/lt/trbc/b, 8618A. **F6c**: ABSP/lt/tr/b, 8626, 8627. PIMO/lt/trbc/b, 8628. PIMO/lt/tr/b, 8629, 8631. PIMO/lt/trbc/b, 8632. TSME/dt/trbc/w, 8624C. **G1b**: CADE/lt/tr/b, 8061. CADE/lt/trbc/b, 8062. CHLA/lt/tr/b, 8072B. CHLA/lt/tr/w, 8072A. COSP/lt/tr/b, 8077. PSME/lt/tr/b, 8060. **G3b**: PSME/lt/trb/b, 7063. **G4a**: PSME/lt/tr/b, 7065, 7067, 7069. PSME/sn/tr/b, 7066. **G4c**: PSME/lt/tr/b, 7077, 7078, 7081, 7083.

Chaenothecopsis cf. *nigra* Tibell — Rare over bark and wood of conifers. Characterized by its short (5–6 μm long), pale spores with a very prominent, dark septum. Due to scanty material, this taxon is not well understood. Total four specimens.

A7a: PSME/lt/trbc/b, 8256. **A7b**: TSHE/lt/tr/b, 8265. **B6**: PSME/sn/tr/w, 8386. **E3a**: COSP/sn/tr/w, 8523.

Chaenothecopsis nigripunctata Rikkinen — Infrequent over resin and wetwood of *Tsuga heterophylla* at lower elevations. Prefers suppressed trees in old-growth forests and often occurs in very deep shade (Rikkinen 2003a). Total 15 specimens.

B2b: TSHE/lt/trc/re, 8496, 8500. **B2c**: TSHE/lt/trc/re, 8298W, 8342W, 81328, 81338, 82217, 82227, 82237, 83473, 83485. **B9**: TSHE/lt/trc/re, 8485. **D4**: TSHE/lt/trc/re, 8658, 8664. TSHE/lt/trbc/re, 8659.

Chaenothecopsis oregana Rikkinen — Infrequent (probably overlooked) over resin and resin impregnated wood of *Abies* and *Tsuga* species in mature montane forests. Also on scarred *Abies grandis* in low elevation riparian forests (Rikkinen 2003b). Total eight specimens.

A3a: TSHE/lt/tr/re, 8333. **C3**: ABGR/lt/trb/re, 8363. **C4**: ABGR/dt/tr/re, 8418. **D4**: ABSP/lt/trbc/re, 8671, 8679. **E3a**: ABLA/dt/trc/re, 8507. ABSP/lt/trc/re, 8526. **E3b**: ABSP/dt/trc/re, 8530.

Chaenothecopsis parasitaster (Bagl. & Car.) D. Hawksw. — Rare, found only once growing on basal squamules of *Cladonia* on a conifer snag. This species should be critically compared with *Chaenothecopsis pusilla* when more material becomes available (Peterson & Rikkinen 1999). Total one specimen.

B1: PSME/lt/tr/b, 8207.

Chaenothecopsis pusilla (Ach.) A.F.W. Schmidt — Frequent over bark and wood in conifer forests at all elevations. Highly variable which respect to ascoma size and shape, spore characteristics and excipulum and stalk structure, certainly representing an as yet unresolved complex of several taxa. Total 69 specimens.

A3a: PSME/lt/tr/b, 8336. **A3b**: TSHE/lt/trbc/b, 8455. **A4**: TSHE/lt/tr/b, 7308. **A5a**: PSME/lt/trb/b, 8151. **A6a**: COSP/stn/tr/w, 8169. PISI/lt/tr/b, 8172, 8173, 8175. **A6b**: PISI/lt/trb/b, 8180. **A7b**: PSME/lt/tr/b, 8262. **A8**: PISI/lt/trbc/b, 8101. PSME/lt/tr/b, 8094. PSME/sn/tr/w, 8103. **B1**: PSME/lt/tr/b, 8206. **B2a**: PSME/lt/tr/b, 7165. THPL/lt/tr/b, 7163. **B4**: PSME/lt/tr/b, 8306. THPL/lt/tr/b, 8285, 8297. **B5**: PSME/lt/tr/b, 8124. **B6**: PSME/sn/tr/w, 8375. **B7**: COSP/sn/tr/w, 8283. PSME/lt/tr/b, 8272. PSME/sn/tr/w, 8270, 8279, 8399, 8401, 8405. **B9**: PSME/lt/tr/b, 8474. **B10a**: THPL/lt/tr/b, 6108, 6111. **C1**: ABGR/lt/tr/b, 8026. PSME/lt/tr/b, 8005, 8018, 8022. PSME/sn/tr/b, 8017. **C2**: ABSP/lt/tr/b, 7238, 7241. PSME/log/tr/w, 7234. PSME/lt/tr/b, 7262, 7282. **C3**: ALRU/stn/trc/w, 7329. **C6**: QUGA/dt/br/b, 7218. QUGA/log/br/w, 7198. **C7a**: ACMA/lt/trbc/b, 7210. **C8a**: ABSP/lt/trb/b, 7120. PSME/lt/tr/b, 7118. **D1a**: ABPR/dt/tr/b, 7006, 7017. ABPR/lt/trbc/w, 7008A. ABPR/sn/tr/w, 7002. ABPR/sn/trbc/w, 7011, 7013A. ABPR/sn/tr/w, 7013B, 7024C. **D2**: ABSP/lt/tr/b, 6132. **D3a**: COSP/sn/tr/w, 6039. **D6b**: PSME/stn/trb/b, 7031C. **E2**: PSME/dt/tr/b, 6093. **E3a**: COSP/sn/tr/w, 8523. **F6a**: TSME/sn/tr/w, 8602. **F6b**: TSME/lt/trbc/w, 8622. **F6c**: ROCK/-/-/detr, 8624B. TSME/lt/trbc/w, 8635. **G1b**: COSP/lt/tr/b, 8077. PSME/lt/tr/b, 8060. **G2**: CHLA/lt/tr/b, 7093. **G4c**: PSME/lt/tr/b, 7083.

Chaenothecopsis pusiola (Ach.) Vain. — Frequent over wood and bark of conifers in aged montane forests and in the Willamette Valley. Infrequent in closed low-elevation rain-

forests (Peterson & Rikkinen 1999). Total 33 specimens.

A1: TSHE/sn/tr/w, 8450. **B5**: PSME/lt/tr/b, 8121, 8124. **B7**: PSME/sn/tr/w, 8279. **B10b**: PSME/sn/tr/w, 6116, 6117. **C1**: ABGR/lt/tr/b, 8023. PSME/lt/tr/b, 8019. **C3**: ABGR/lt/tr/b, 8369. ACMA/lt/trc/w, 7333. **C8a**: PSME/lt/tr/b, 7115. **C8b**: COSP/fp/trb/w, 8035, 8040. **D1a**: ABPR/dt/tr/b, 7018. ABPR/sn/tr/b, 7024C. ABPR/sn/tr/w, 7002, 7004, 7013B, 7022. **D3b**: ABSP/lt/tr/b, 6044. **D5**: TSHE/lt/tr/b, 7045. **E1**: THPL/lt/tr/b, 6071. **E2**: COSP/sn/tr/w, 6097. **E3b**: PSME/sn/tr/w, 8532. **E6**: PIPO/sn/tr/w, 8315, 8329. **F2**: ABSP/sn/tr/w, 8651. CHNO/lt/tr/b, 8650. **F4**: TSME/sn/tr/w, 8556. **G2**: LIDE/sn/tr/b, 7086. PSME/dt/trc/w, 7088. PSME/lt/tr/b, 7085. **G4c**: PSME/stn/tr/w, 7082.

Chaenothecopsis rubescens Vain. — Rare over bark and wood of old hardwoods in the Willamette Valley (Rikkinen 1998, Peterson & Rikkinen 1999). Total five specimens.

C8b: QUGA/lt/tr/b, 8029, 8031, 8039, 8041. QUGA/lt/tr/w, 8034.

Chaenothecopsis cf. *rubina* Tibell — Rare over wood and bark of conifers in humid low-elevation forests. Due to scanty material, this species is not well understood. Characterized by its deep red, K+ dark green ascomata and narrowly ellipsoidal, 1-septate spores. In two collections the ascomata are accompanied with stalked, K+ green pycnidial anamorphs (Peterson & Rikkinen 1999). Total five specimens.

A3b: PSME/lt/tr/b, 8458. **A5a**: PISI/sn/trbc/w, 8137. **A7a**: PSME/lt/trbc/b, 8256. **A7b**: PSME/lt/trbc/b, 8259. **G7b**: PSME/stc/tr/b, 7080.

Chaenothecopsis savonica (Räsänen) Tibell — Frequent over wood and rotten bark, mainly in very humid microhabitats at lower elevations (Peterson & Rikkinen 1999). Total 21 specimens.

A2a: PISI/sn/tr/w, 7129. **A7a**: PSME/lt/trbc/b, 8256. PSME/sn/tr/w, 8255. **A7b**: PSME/lt/tr/b, 8257. **A10a**: SESE/lt/trc/w, 8247. **B2a**: PSME/lt/tr/b, 7165. **B4**: PSME/lt/tr/b, 8304. THPL/lt/tr/b, 8288. **B5**: ALRU/sn/trb/w, 8115. **B7**: THPL/sn/tr/w, 8282. **B9**: PSME/sn/tr/w, 8468. **C2**: PSME/lt/tr/b, 7229. **C5**: QUGA/sn/tr/w, 7170. **D1a**: ABPR/sn/tr/b, 7024C. **D2**: ABSP/lt/tr/b, 6132. PSME/lt/trb/b, 6141. **D6b**: PSME/stn/trb/w, 7031B. **E2**: COSP/sn/tr/w, 6088. **E6**: PIPO/sn/tr/w, 8329. **G1b**: CADE/lt/trbc/w, 8062. **G2**: PSME/sn/trbc/w, 7091.

Chaenothecopsis sitchensis Rikkinen — Rare, but locally frequent over resin and resin impregnated bark and lignum on basal trunks of *Picea sitchensis* and *Tsuga heterophylla*. Prefers extremely sheltered microhabitats and usually occurs under slabs of dead bark or in deep caves between roots of huge old-growth *P. sitchensis*. Restricted to old-growth rainforests in the *Picea sitchensis* Zone (Rikkinen 1999). Total 26 specimens.

A1: PISI/lt/trc/re, 8433, 8434, 8435, 8441, 8442. PISI/sn/tr/re, 8448. TSHE/lt/trc/re, 8446, 8447. **A2d**: PISI/lt/trbc/re, 8393, 8394, 8395. **A3a**: PISI/lt/tr/re, 8340. **A3b**: PISI/lt/trb/re, 8453, 8454, 8457. **A5a**: PISI/lt/trbc/re, 8138, 8144, 8146, 8149. PISI/sn/trbc/re, 8137. **A6b**: PISI/lt/tr/re, 8186. PISI/lt/trb/re, 8180. PISI/lt/trbc/re, 8183, 8184, 8189. **A8**: PISI/lt/trbc/re, 8099.

Chaenothecopsis subparoica (Nyl.) Tibell — Rare over leprose lichens on bryophyte and plant litter on vertical and overhanging cliffs. Probably a frequent but overlooked species within the Columbia Gorge (Peterson & Rikkinen 1999). Total two specimens.

B1: ROCK/-/-/rock, 8223. **B3**: ROCK/-/-/detr, 7179.

Chaenothecopsis tsugae Rikkinen — Rare over resin and wetwood of *Tsuga heterophylla* in low elevation riparian forests (Rikkinen 1999). Selva and Tibell (1999) reported this species from British Columbia as '*Chaenothecopsis thujae*'. Total two specimens.

A3a: TSHE/lt/trbc/re, 8352. **B4**: TSHE/lt/trbc/re, 8309.

Chaenothecopsis ussuriensis Titov — Rare (probably overlooked) over bark and wood of aged conifers in mature forests at lower elevations (Peterson & Rikkinen 1999). Total nine specimens.

A3a: THPL/lt/tr/b, 8356. **A7a**: PSME/lt/trbc/b, 8256. **A7b**: TSHE/lt/tr/b, 8258. **B1**: PSME/lt/tr/b, 8206. **B4**: THPL/lt/tr/b, 8285. **F6c**: TSME/lt/trbc/w, 8635. **G1b**: CADE/lt/trbc/w, 8062. COSP/lt/tr/b, 8074. PSME/lt/tr/b, 8060.

Chaenothecopsis cf. *vainioana* (Nádv.) Tibell — Frequent over bark and lignum at lower elevations, especially in mixed forests of the Willamette Valley and in riparian forests of

the *Tsuga heterophylla* Zone. This is probably a complex of two or more species. All the specimens have 1-septate, relatively long (6–10 μm) ascospores and grow on *Trentepohlia* or crustose lichens with trentepohlioid photobionts. Total 20 specimens.

A4: TSHE/lt/tr/b, 7315. **B2a**: THPL/lt/tr/b, 7164. **B2c**: PSME/sn/tr/w, 8300, 8352. **B4**: THPL/lt/tr/b, 8287, 8301, 8305. **B7**: PSME/lt/tr/b, 8271. **B9**: THPL/lt/tr/b, 8488. **C1**: ABGR/lt/tr/b, 8007. **C2**: ABSP/lt/tr/b, 7241. **C3**: ACMA/lt/trc/w, 7333. **C4**: ABGR/dt/tr/b, 8417. ABGR/lt/tr/b, 8419. **C7a**: ACMA/lt/trbc/w, 7215. ACMA/sn/trbc/w, 7207, 7211. QUGA/lt/tr/b, 7166. **G6c**: ABCO/lt/tr/b, 2013A, 2020.

Chaenothecopsis viridialba (Kremp.) A.F.W. Schmidt — Rare, found only once growing on decorticated wood of a huge conifer snag in a semi-open conifer forest east of the Cascade Crest (Peterson & Rikkinen 1999). Total one specimen.

E2: COSP/sn/trbc/w, 6078.

Chaenothecopsis viridireagens (Nádv.) A.F.W. Schmidt — Frequent on and around *Chaenotheca* species over wood and bark of conifers in humid low-elevation forests. Populations with ascomata are not very common, but when produced, ascomata can often occur in enormous numbers. The teleomorph is invariably accompanied by a distinctive pycnidial anamorph (Tibell 1993, 1997). Similar anamorphs are also common in calicioid specimens without *C. viridireagens* ascomata. They have a wider distribution than the teleomorphs, especially in coastal and middle elevation forests. Calicioid specimens with stalked anamorphs are listed separately as they might actually belong to several different *Chaenothecopsis* species (Peterson & Rikkinen 1999). Total nine specimens with ascomata; 57 specimens with stalked pycnidial anamorphs.

Ascomata: **B3**: COSP/stc/tr/w, 7178. **B4**: PSME/lt/tr/b, 8304. **B9**: PSME/sn/tr/b, 8479. **B10b**: PSME/stn/tr/w, 6118. **C1**: COSP/sn/tr/w, 8013. **C2**: PSME/sn/trbc/w, 7335. **D3a**: COSP/sn/tr/w, 6039, 6028. PSME/sn/tr/w, 8510. **Stalked pycnidial anamorphs**: **A1**: PISI/sn/tr/w, 8444, 8448. **A3b**: PSME/lt/tr/b, 8463. **A5a**: PISI/sn/trbc/w, 8137. PSME/sn/tr/w, 8155. **A6a**: PISI/lt/tr/b, 8162. **A6b**: THPL/lt/tr/b, 8178. **A10a**: SESE/lt/tr/b, 8237, 8239. **B1**: PSME/lt/tr/b, 8207. **B2a**: THPL/lt/trbc/b, 7162. **B4**: PSME/lt/tr/b, 8304. THPL/lt/tr/w, 8286. THPL/lt/tr/b, 8287. **B5**: ALRU/sn/trb/w, 8115. PSME/lt/tr/b, 8113, 8121, 8124. PSME/sn/tr/w, 8108, 8117, 8120, 8127, 8135. PSME/stn/tr/w, 8130. **B6**: PSME/sn/tr/w, 8381. **B7**: COSP/sn/tr/w, 8283. PSME/lt/tr/b, 8398. PSME/sn/tr/w, 8405, 8406. THPL/lt/tr/b, 8281. **B10a**: COSP/log/ro/b, 6113. COSP/sn/tr/w, 6114. THPL/lt/tr/b, 6108, 6112. **B10b**: PSME/stn/tr/w, 6118. **C1**: COSP/sn/tr/w, 8013, 8014. COSP/stn/trbc/w, 8009, 8015. PSME/lt/trb/b, 8016. PSME/lt/tr/b, 8018, 8020, 8022. **C2**: PSME/lt/tr/b, 7233, 7336. PSME/sn/tr/w, 7237. **C3**: ABSP/lt/tr/b, 7326. ACMA/lt/trc/w, 7333. PSME/lt/tr/b, 7330, 8362. **C4**: PSME/lt/tr/b, 8415. **D1a**: ABPR/sn/tr/w, 7002, 7004. **D3a**: COSP/sn/tr/w, 6028. **D4**: TSHE/lt/tr/b, 8672. **G2**: CHLA/lt/tr/b, 7093. PSME/sn/trbc/w, 7091.

Chaenothecopsis sp. 1 — Rare (probably overlooked) over hard lignum in very exposed habitats at high elevations. Characterized by its medium-sized to large (1–2 mm) ascomata, with stout, pale stalks and obconical to lenticular, reddish brown capitula. Stalk consisting of irregularly interwoven, non-pigmented hyphae and especially the stalk base swelling strongly with KOH. Excipulum poorly developed, consisting of more or less cylindrical, periclinally arranged, reddish brown hyphae. Hypothecium and hymenium pale, in some specimens K+ aeruginose. Also the excipulum can be K+ aeruginose, slowly turning back to reddish brown. Ascus cylindrical, 50–55 μm long, with a thickened apex penetrated by a short canal. Spores non-septate, relatively large (6–9 × 3–4 μm), pale brown, ellipsoidal with rounded ends. Some asci in the Californian specimens have contained only 1–2 deformed, gigantic ascospores (up to 27 × 4 μm). Total three specimens.

E4: SASP/dt/br/w, 8565. **G12**: PILO/lt/trc/w, 2034, 2035.

Mycocalicium albonigrum (Nyl.) Tibell — Apparently rare, but possibly overlooked over hard lignum at high elevations. Total three specimens.

D5: TSHE/lt/trc/w, 7049. **G9**: POTR/stc/trb/w, 2041. COSP/sn/tr/w, 2042.

Mycocalicium sequoiae Bonar — Rare, found twice on the exudate of *Sequoiadendron giganteum*. Forms massive colonies in deep burns and other wounds where there has been a flow of exudate from the heartwood. Has also

been collected from the exudate of *Sequoia sempervirens* (Bonar 1971). Total two specimens.

G5: SEGI/lt/trc/re, 2055, 2057.

Mycocalicium subtile (Pers.) Szatala — Frequent over wood of conifers in montane forests and in the Willamette Valley. Also on exposed lignum near the Pacific Coast, but almost absent from snags in closed low-elevation rainforests. Highly variable which respect to ascoma size and shape, spore characteristics and excipulum structure, probably representing an unresolved complex of closely related taxa (de Los Angeles Vinuesa *et al*. 2001). Total 132 specimens.

A2a: PISI/sn/tr/w, 7133. **A3a**: COSP/stn/tr/w, 8353. PISI/sn/tr/w, 8355. **A4**: PISI/sn/tr/w, 7311. **A5a**: PISI/sn/tr/w, 8158. **A5b**: PISI/sn/tr/w, 8159, 8160. **A10a**: SESE/lt/trbc/w, 8248. **A12**: PIMU/sn/tr/w, 2065. **A13b**: QUKE/dt/trc/w, 2063. **B2a**: THPL/lt/tr/b, 7160, 7164. **B4**: PSME/lt/tr/w, 8300. **B9**: PSME/sn/tr/w, 8469. **C1**: ALRU/lt/tr/w, 8004. COSP/sn/tr/w, 8028. **C2**: TABE/sn/tr/w, 7240. **C3**: COSP/sn/tr/w, 7346. PSME/stn/trc/w, 7342. TABE/dt/tr/w, 7336. **C4**: FRLA/dt/tr/w, 8431. **C5**: QUGA/sn/tr/w, 7170. **C7b**: ACMA/sn/tr/w, 7249. **C8b**: QUGA/lt/trc/w, 8030. **D1a**: ABPR/sn/tr/w, 7013B, 7024B. **D2**: COSP/sn/tr/w, 6127, 6131. **D3b**: ABSP/sn/tr/w, 6051. COSP/sn/tr/w, 6049. **D3c**: TSME/sn/tr/w, 6056, 6057. **D4**: ABSP/sn/tr/w, 8669. **D5**: PSME/sn/tr/w, 7050B. **D6a**: PICO/dt/tr/w, 7025. PICO/lt/br/w, 7027, 7028. PSME/log/tr/w, 7026. **D6b**: PSME/sn/tr/w, 7034. PSME/stn/trb/w, 7031A. **D7**: COSP/sn/tr/w, 6102, 6105A. **E2**: COSP/sn/tr/w, 6078, 6088. **E3a**: ABLA/dt/trc/w, 8507. ABSP/lt/trc/w, 8514. **E3b**: ABSP/dt/trc/w, 8530, 8535. ABSP/sn/tr/w, 8529. PIEN/lt/trc/w, 8533. PIMO/sn/tr/w, 8539. PSME/lt/trc/w, 8536. **E4**: PIPO/log/tr/w, 8562. PIPO/sn/tr/w, 8560, 8566, 8567. SASP/sn/tr/w, 8568. **E5**: PIAL/sn/tr/w, 8590. PIPO/sn/tr/w, 8580, 8582, 8583, 8584, 8585, 8586. **E6**: ABSP/sn/tr/w, 8322. COSP/sn/tr/w, 8312. PIPO/sn/tr/w, 8313, 8314, 8327, 8329, 8332. **F1**: ABSP/lt/tr/w, 6074. ABSP/sn/tr/w, 6076, 6077. **F2**: ABPR/sn/tr/w, 8640, 8641. CHNO/sn/tr/w, 8639. CHNO/sn/trb/w, 8643. **F3**: COSP/sn/tr/w, 7039, 7040. **F4**: ABSP/lt/trc/w, 8553. COSP/sn/tr/w, 8549, 8551. TSME/sn/tr/w, 8556. **F5**: ABLA/sn/tr/w, 8593, 8596. PIAL/sn/tr/w, 8591. **F6a**: TSME/sn/tr/w, 8601, 8603, 8604. **F6b**: COSP/sn/tr/w, 8610. PICO/sn/tr/w, 8609. **F6c**: PICO/sn/tr/w, 8633. PIMO/sn/tr/w, 8634. TSME/sn/tr/w, 8630. **G1b**: CADE/lt/trc/w, 8055. CADE/sn/tr/w, 8069. PIPO/sn/tr/w, 8056, 8059, 8063, 8064, 8065, 8081. PSME/sn/tr/w, 8071A. **G3a**: CADE/sn/trb/w, 7055, 7056, 7059, 7054. **G3b**: CADE/lt/trb/w, 7064. **G4a**: PSME/stc/tr/w, 7070. **G4b**: ARME/lt/trbc/w, 7072. QUCR/sn/tr/w, 7073. QUCR/sn/trbc/w, 7074. **G5**: ABCO/lt/tr/b, 2053. PILA/sn/tr/w, 2061. **G6c**: COSP/stn/trb/w, 2015. COSP/log/trb/w, 2016. COSP/sn/trb/w, 2017, 2019. ABCO/lt/br/w, 2013B. **G7**: PIPO/log/trb/w, 2048. **G8**: PIPO/stn/trb/w, 2047. **G9a**: COSP/sn/tr/w, 2043, 2045. COSP/log/tr/w, 2046. **G9b**: PIAL/sn/tr/w, 2049. **G10**: COSP/log/tr/w, 2040, 2050. **G11**: PIFL/stn/trb/w, 2036, 2037. PICO/sn/tr/w, 2039.

Mycocalicium cf. *victoriae* (C. Knight *ex* F. Wilson) Tibell — Rare on decorticated conifer wood in humid forests at low and middle elevations. Characterized by its medium-sized, stout ascomata with obconical or lenticular capitula and a well developed excipulum. Ascomata epruinose and shiny black in incident light. Excipulum consisting of isodiametric (3–7 μm in diam.) cells, with cylindrical, horizontally arranged hyphae in the upper part. Stalk surface of periclinally arranged, sparsely intertwined, brownish hyphae, 5–6 μm in diam. Inner part of the stalk pale. Ascomata KOH–, swelling strongly with KOH. Spores non-septate, distinctly brown and smooth, ellipsoidal to fusiform, 6–8(9) μm long. Variation of this species is not well understood and several specimens may have been misidentified as *M. subtile*. Some specimens should also be compared with *Mycocalicium anomalum* Tibell. Total two specimens.

C3: TABE/sn/tr/w, 7340. **D4**: TSHE/lt/trbc/w, 8660.

Phaeocalicium compressulum (Szatala) A.F.W. Schmidt — Infrequent, but probably much overlooked over twigs and thin branches of *Alnus* at higher elevations (Peterson & Rikkinen 1999). Total five specimens.

B10b: ALRU/dt/tw/b, 6121. **D2**: ALSI/lt/tw/b, 6123. **D7**: ALSI/lt/tw/b, 6105B. **E3b**: ALSI/lt/tr/b, 8544. **F2**: ALSI/sn/tr/w, 8636.

Phaeocalicium matthewsianum Selva & Tibell — Rare, found only once on a dead twig of *Alnus rubra* in a riparian montane forest. Probably overlooked. The specimen, although very scanty, corresponds well with the specimens described from eastern North America (Selva & Tibell 1999). Mature spores are brown, 3-septate, 15–19 × 4.5–7 μm, and slightly ornamented under the light microscope. Total one specimen.

D4: ALRU/dt/tw/b, 8680.

Phaeocalicium populneum (Duby) A.F.W. Schmidt — Infrequent, but probably much overlooked over twigs and thin branches of *Populus*

at all elevations (Peterson & Rikkinen 1999). Total eight specimens.

B1: POTR/lt/tw/b, 8200, 8201, 8202. **C7a**: ACMA/lt/trbc/w, 7214. POTR/lt/tw/b, 7209, 7213. **D6c**: POTR/lt/tw/b, 7038. **G4c**: POTR/lt/tw/b, 7084.

Phaeocalicium sp. 1 — Infrequent (probably overlooked) over rough bark of conifers in humid old-growth forests at middle elevations in the Klamath Region and Sierra Nevada. Very easily overlooked. Characterized by its tiny (0.2–0.4 mm) ascomata, shiny black under incident light, greenish-brown under the light microscope. Capitulum ovoid, with constricted excipular margins. Excipulum surface with isodiametric cells, ca. 5 μm in diam. Stalk of mostly periclinally arranged, sparsely intertwined, brownish hyphae, 3–6 μm in diam.; stalk base pale, with strongly gelatinized hyphae. Ascus cylindrical, 80–100 μm long, ascus apex not thickened. Spores 1-septate, greenish brown, widely ellipsoidal, 13–15(17) × 6–7 μm, with pointed ends and with a distinct, rough surface ornamentation. The septum is thick but not pigmented. Total five specimens.

G4a: PSME/lt/tr/b, 7067. **G6a**: ABCO/lt/tr/b, 2001. **G6c**: ABCO/sn/tr/b, 2021. ABCO/lt/tr/b, 2027, 2028.

Phaeocalicium sp. 2 — Locally frequent on hardwood twigs and thin branches in the Willamette Valley. The ascomata appear in winter and can be abundant on second year branches of *Fraxinus latifolia* in riparian forests. Morphological variation of this species is not adequately understood. It is closely allied with *Phaeocalicium interruptum* and is perhaps more appropriately included in this species (Tibell 1996). It should also be critically compared with *Phaeocalicium* sp. 3 when more specimens become available. Characterized by its small (0.2–0.4 mm) ascomata with pale stalk and dark brown, distinctly campanulate capitula. Excipulum surface with isodiametric to irregular, sclerotized cells, forming a mosaic in surface view. Upper part of the excipulum distinctly widened. Stalk consisting of largely periclinally arranged, slightly intertwined, pale hyphae. Ascus cylindrical, 60–65 μm long, with an uniformly thickened apex. Spores non-septate, sometimes later developing a single septum, dark brown, ellipsoidal with rounded ends, 9–11 × 3.5–4.5(6) μm, smooth. Total 12 specimens.

C4: FRLA/lt/tw/b, 8412. **C6**: QUGA/lt/tw/b, 7204, 7216. **C7a**: FRLA/lt/tw/b, 7205A–7205E, 7206. **C7b**: FRLA/lt/tw/b, 7231A, 7231B. **G1b**: QUGA/lt/tw/b, 8054.

Phaeocalicium sp. 3 — Rare, but probably overlooked on twigs and thin branches of hardwoods in humid montane forests. The material available is too scarce for the species to be adequately described. It is closely allied with *Phaeocalicium interruptum* and is perhaps more appropriately included in this species. Characterized by its small (0.2–0.3 mm) ascomata with pale stalk and dark brown, campanulate capitula. Excipulum surface with isodiametric to irregular, sclerotized cells, forming a mosaic in surface view. Upper part of the excipulum distinctly widened, with cylindrical, horizontally arranged hyphae in the uppermost part. Stalk consisting of largely periclinally arranged, slightly intertwined, pale hyphae. Ascus cylindrical, 60–70 μm long, with an uniformly thickened apex (ca. 3 μm). Spores non-septate when inside the asci, but soon 1-septate, brown, ellipsoidal, 10–13(15) × 4–5(6) μm, with coarse, aerolate ornamentation of irregular brown plates separated by narrow, pale cracks. The septum is thick but not pigmented. Total two specimens.

B9: QUGA/lt/tw/b, 8492. **D4**: SOSI/dt/br/b, 8674.

Stenocybe clavata Tibell — Frequent over conifer bark in humid forests at low elevations, especially in mature rainforests of the *Picea sitchensis* and *Tsuga heterophylla* Zones. Seems to often produce its ascomata on conifer bark covered by *Ochrolechia* species (Peterson & Rikkinen 1999). Total 52 specimens.

A1: TSHE/lt/tr/b, 8449. **A2c**: PISI/lt/tr/b, 7148. **A3a**: PSME/lt/tr/b, 8336, 8341. **A3b**: PSME/lt/tr/b, 8465. **A4**: PSME/lt/tr/b, 7305. TSHE/lt/tr/b, 7303, 7304, 7308, 7314, 7315, 7318. **A5a**: PSME/lt/trb/b, 8150, 8151. **A6a**: PSME/lt/tr/b, 8165, 8168. TSHE/lt/tr/b, 8171, 8176. **A7a**: PSME/lt/tr/b, 8251. PSME/lt/trbc/b, 8256. **A7b**: PSME/lt/tr/b, 8262, 8268. PSME/lt/trb/b, 8261. PSME/lt/trbc/b, 8269. TSHE/lt/tr/b, 8260, 8266. **A8**: PSME/lt/tr/b, 8088, 8089, 8093. PSME/stn/tr/b, 8091. TSHE/lt/tr/b, 8096. **B4**: PSME/lt/tr/b, 8306. **B5**: PSME/lt/tr/b, 8111, 8113, 8121–8125, 8131, 8136.

B6: PSME/lt/tr/b, 8376, 8378. **B7**: PSME/lt/tr/b, 8276. **B9**: PSME/lt/tr/b, 8470. TSHE/lt/tr/b, 8495. **C2**: PSME/lt/tr/b, 7230, 7261. **C4**: PSME/lt/tr/b, 8420, 8424. **D1a**: ABPR/lt/tr/b, 7003. **D1b**: PSME/lt/tr/b, 6000. **E2**: PSME/dt/tr/b, 6093.

Stenocybe fragmenta Peterson & Rikkinen — Rare, found only once on shaded twigs of *Rhamnus purshiana* in a river-side park in Corvallis. Probably overlooked (Peterson & Rikkinen 1998). Total one specimen.

C7c: RHPU/lt/tw/b, 8506.

Stenocybe major Koerb. — Frequent over smooth bark of *Abies* species. Most common in the *Abies amabilis* Zone, but also at lower elevations. Total 22 specimens.

C3: ABSP/lt/tr/b, 7348. **C4**: ABGR/dt/tr/b, 8417. ABGR/lt/tr/b, 8422. **D1a**: ABPR/lt/tr/b, 7001. **D2**: ABSP/lt/tr/b, 6137A. **D3a**: ABSP/lt/tr/b, 6023. **D3b**: ABSP/lt/tr/b, 6044, 6048. **D4**: ABSP/lt/tr/b, 8663. **D6a**: ABSP/lt/br/b, 7029. **D7**: ABSP/lt/tr/b, 6101. **E3a**: ABLA/lt/tr/b, 8511. ABSP/dt/tr/b, 8522. **E3b**: ABSP/lt/trc/b, 8531. ABSP/lt/trc/w, 8541. **E4**: ABSP/lt/tr/b, 8579. **E5**: ABGR/lt/tr/b, 8588. **E6**: ABSP/dt/tr/b, 8317. ABSP/lt/tr/b, 8319. **F2**: ABAM/lt/tr/b, 8642, 8649. **F4**: ABLA/lt/tr/b, 8547.

Stenocybe pullatula (Ach.) Stein — Frequent over bark of *Alnus rubra* in riparian forests at lower elevations. Most common on twigs and thin branches (Peterson & Rikkinen 1999). Total 18 specimens.

A1: ALRU/lt/tw/b, 8438. **A10b**: ALRU/lt/tw/b, 7098. **A3a**: ALRU/lt/tw/b, 8347. **A3b**: ALRU/lt/tw/b, 8459. **A6b**: ALRU/lt/tw/b, 8179, 8187. **B4**: ALRU/lt/tw/b, 8307. **B5**: ALRU/lt/br/b, 8116. **B6**: ALRU/lt/br/b, 8383. ALRU/sn/br/b, 8373. ALRU/sn/tr/b, 8390. **B7**: ALRU/lt/tw/b, 8396. **B10b**: ALRU/lt/tr/b, 6122. **C3**: ALRU/lt/trb/b, 8357. ALRU/lt/tw/b, 8365. **C4**: ALRU/dt/tw/b, 8429. SASP/lt/tw/b, 8411. **D4**: ALRU/sn/tw/b, 8680.

Microcaliciaceae

Microcalicium ahlneri Tibell — Frequent over decorticated conifer wood and rotten bark in humid conifer forests. Prefers large conifer snags and logs in old-growth forests (Peterson & Rikkinen 1999). Total 29 specimens.

A5a: PSME/sn/tr/w, 8155. **B1**: THPL/sn/tr/w, 8219. **B2a**: THPL/lt/tr/b, 7164. **B4**: THPL/lt/tr/b, 8305. PSME/sn/tr/w, 8294. PSME/lt/tr/b, 8304. **B5**: PSME/sn/tr/w, 8108–8110, 8114, 8120, 8135. **B6**: PSME/sn/tr/w, 8371, 8387. **B7**: PSME/sn/tr/w, 8274. COSP/sn/tr/w, 8283. **C1**: PSME/lt/tr/b, 8020. **C2**: PSME/lt/tr/b, 7230, 7233. PSME/log/tr/w, 7234. **C3**: PSME/lt/tr/b, 7331. **D5**: PSME/sn/tr/w, 7050A. **D6b**: PSME/stn/trb/w, 7031B. PSME/sn/tr/w, 7034. PSME/log/tr/w, 7031D. **E3a**: PSME/sn/tr/w, 8510. **G2**: PSME/dt/trc/w, 7087. CHLA/lt/tr/b, 7093. **G4c**: PSME/stn/tr/w, 7082.

Microcalicium arenarium (Hampe *ex* A. Massal.) Tibell — Rare over green algae and leprose lichens on overhanging, shaded cliffs. Probably a frequent but overlooked species within the Columbia Gorge. Total two specimens.

B1: ROCK/-/-/rock, 8203. **B3**: ROCK/-/-/rock, 7180.

Microcalicium disseminatum (Ach.) Vain. — Frequent over conifer bark and wood in mature conifer forests. Most common in montane forests and apparently absent from the *Picea sitchensis* Zone (Peterson & Rikkinen 1999). Total 38 specimens.

B1: THPL/lt/tr/b, 8212. PSME/lt/tr/b, 8207. **B2a**: THPL/lt/tr/b, 7160. THPL/lt/trbc/b, 7162. PSME/lt/tr/b, 7161, 7165. **B4**: THPL/lt/tr/b, 8285, 8301. THPL/lt/tr/w, 8286. PSME/lt/tr/b, 8306. **B7**: PSME/lt/tr/b, 8397. **B9**: THPL/lt/tr/b, 8484, 8487. PSME/lt/tr/b, 8475. **B10a**: THPL/lt/tr/b, 6108. **C1**: COSP/sn/tr/w, 8013. **C2**: PSME/sn/tr/w, 7237. **C5**: QUGA/sn/tr/w, 7174. **C6**: QUGA/dt/br/b, 7218. **D3a**: PSME/lt/tr/b, 6030, 6037. **D4**: PSME/lt/tr/b, 8665. **D6b**: PSME/stn/trb/w, 7031A. PSME/stn/trb/b, 7031C. **E1**: THPL/lt/tr/b, 6061. **E2**: PSME/dt/tr/b, 6093. **E3b**: PSME/lt/tr/b, 8540. **F6c**: PIMO/lt/trbc/b, 8628. PIMO/lt/tr/b, 8631. **G1b**: PSME/lt/tr/b, 8060. COSP/lt/tr/b, 8074, 8077. CADE/lt/trbc/w, 8062. **G4a**: PSME/sn/tr/b, 7066. PSME/lt/tr/b, 7065, 7067. **G4c**: PSME/lt/tr/b, 7077, 7083.

Sphinctrinaceae

Sphinctrina leucopoda Nyl. — Rare, found only once on a living twig of *Acer macrophyllum* in an aged riparian forest in the foothills of the Willamette Valley. Probably overlooked (Peterson & Rikkinen 1999). Total one specimen.

C3: ACMA/lt/tw/b, 8368.

Incertae sedis

Brucea castoris Rikkinen — Rare over resin and

resin impregnated wood in low elevation riparian forests. Collected twice from large beaver scars on mature *Abies grandis* and once from a deep beaver scar on the basal trunk of *Tsuga heterophylla* (Rikkinen 2003b). Total five specimens.

A3a: TSHE/lt/tr/re, 8333. **C1**: ABGR/lt/trbc/re, 8008, 8010, 8024. **C3**: ABGR/lt/trb/re, 8363.

Species diversity

The averge number of calicioid species per field specimen varied, with a mean of 2.1 species per sample unit and a standard deviation of 1.1 species. However, 275 field specimens had at least three different species of calicioids and 41 specimens had six species or more (max. 10 species). There were clear differences in species richness between the major forest zones. The highest number of species and the highest beta diversity were recorded for the *Tsuga heterophylla* Zone, while the lowest number of species and lowest beta diversity were recorded for subalpine forests in the Cascade Range. Some of this variation was undoubtedly attributed to differences in sampling intensity between forest zones (Table 1). The average number of calicioid species per sample unit was relatively high in the forests of the Willamette Valley and in mid-elevation forests of the Cascades. The values for subalpine and Californian forests were slightly lower and comparable to that for the *Tsuga heterophylla* Zone. Field specimens from coastal forests had the lowest average number of calicioid species (Table 1).

Beta diversities were generally high, reflecting the variety of different habitat types and substrates sampled in each forest zone. The large number of infrequent species occurrences also contributed to the high beta diversities. Even when the data were divided into more homogenous groups (by forest zone and/or substrate type), the beta diversities remained rather high (Tables 1 and 2). The species-area curves in Fig. 15 show the number of calicioid species as

Table 2. Basic statistics for some frequent substrate types. Obs.: number of calicioid species observations. Species no.: total number of calicioid species. Spec./sample: average number of calicioid species per sample unit. Beta diversity: total number of species divided by average number of species.

Substrate type	Sample size	Obs.	Species no.	Spec./sample	Beta diversity
Abies bark	80	192	32	2.40	13.33
Abies lignum	65	136	29	2.09	13.88
Picea sitchensis bark	17	37	12	2.18	5.50
Picea sitchensis lignum	18	23	11	1.28	8.59
Pinus wood	48	92	20	1.92	10.42
Pseudotsuga bark	168	501	38	3.04	12.50
Coastal forests	24	50	14	2.08	6.73
Tsuga heterophylla Zone	38	116	26	3.05	8.52
Willamette Valley	48	169	25	3.52	7.10
Montane forests	33	115	21	3.48	6.03
Trunk crevices	25	53	20	2.12	9.43
Pseudotsuga lignum	115	202	25	1.76	14.20
Tsuga heterophylla Zone	69	113	13	1.64	7.93
Montane forests	16	34	14	2.12	6.60
Basal crevices	20	37	16	1.85	8.65
Quercus bark	12	23	14	1.91	7.33
Quercus lignum	24	56	20	2.33	8.58
Thuija bark	31	52	22	1.68	13.10
Tsuga bark	30	57	24	1.90	12.63
Tsuga trunk crevices	48	74	28	1.54	18.18
Unspecified conifer wood	82	201	39	2.45	15.92
Low elev. conif. forests	37	69	24	1.86	12.90
Willamette Valley	14	38	16	2.71	5.90
Montane forests	45	94	27	2.09	12.92

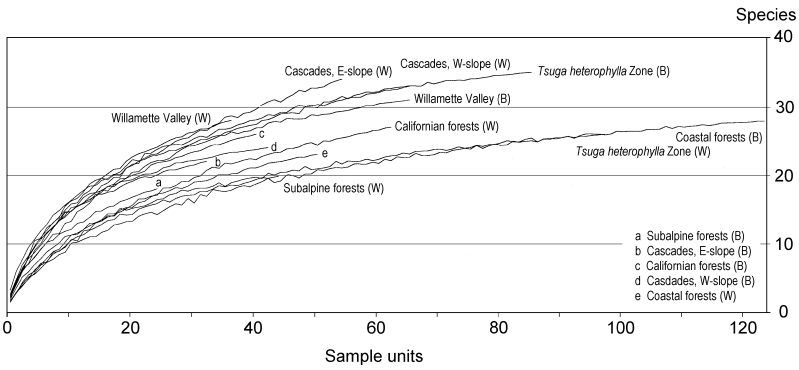

Fig. 15. Number of calicioid species as function of sample size in field specimens of conifer bark (B) and conifer wood (W) from the different forest zones.

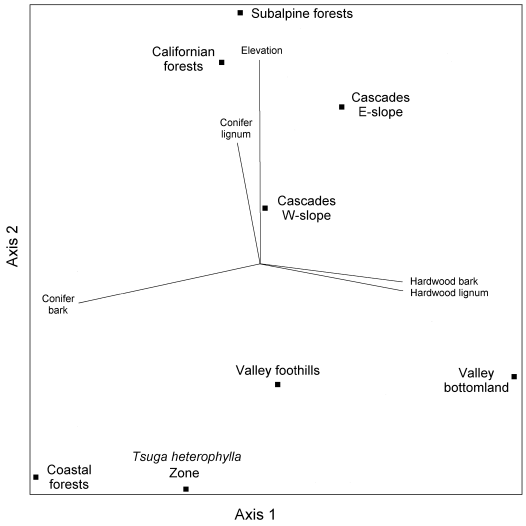

Fig. 16. Ordination of eight forests zones in calicioid species space. Radiating lines indicate the relative strength and direction of correlation of environmental variables with the ordination.

function of sample size in specimens of conifer bark and conifer wood from the different forest zones. Specimens of conifer wood from the Willamette Valley and from mid-elevation forests of the Cascades had a high diversity of calicioids, as did specimens of conifer bark from the Willamette Valley and from the *Tsuga heterophylla* Zone. The species-area curve of decorticated hardwood lignum from the Willamette Valley resembled that of conifer wood from the W slope of the Cascades (curve not shown). Conifer wood from the *Tsuga heterophylla* Zone and from subalpine forests, and conifer bark from coastal forests had relatively low species diversities (Fig. 15).

The occurrences of resinicolous and parasitic calicioids were closely linked to their specific hosts. Putting aside these restraints, most calicioids were not narrowly restricted to one substrate type. Most species grew on bark or lignum or both, with the species-specific preferences varying from slight to pronounced. Thirty-one species (37.8%) occurred predominately over bark, 31 species (37.8%) over decorticated wood, nine

Table 3. Strongest correlations ($r \geq 0.700$) of calicioid species and environmental variables with the ordination axes in Fig. 16. Numbers in boldface = values over 0.7.

Species or variable	Axis 1	Axis 2
Chaenotheca chlorella	**0.846**	–0.193
Calicium salicinum	**0.788**	–0.247
Calicium adaequatum	**0.784**	0.191
Sclerophora peronella	**0.766**	–0.392
Phaeocalicium sp. 2	**0.765**	–0.229
Chaenotheca brachypoda	**0.719**	–0.005
Stenocybe clavata	**–0.749**	–0.683
Calicium lenticulare	**–0.703**	**–0.700**
Chaenotheca furfuracea	–0.653	**–0.779**
Stenocybe pullatula	–0.507	**–0.751**
Chaenotheca brunneola s. lato	–0.669	**–0.717**
Chaenotheca olivaceorufa	–0.361	**–0.706**
Chaenotheca chrysocephala	0.225	**–0.719**
Calicium viride	0.169	**0.985**
Mycocalicium subtile	–0.039	**0.963**
Chaenothecopsis nana	0.017	**0.924**
Chaenotheca trichialis	0.000	**0.770**
Chaenotheca subroscida	0.075	**0.700**
Elevation	0.016	**0.926**
Conifer lignum (% of specimens)	–0.309	**0.716**
Conifer bark (% of specimens)	**–0.870**	–0.401
Hardwood lignum (% of specimens)	**0.778**	–0.278
Hardwood lignum (% of specimens)	**0.773**	–0.336

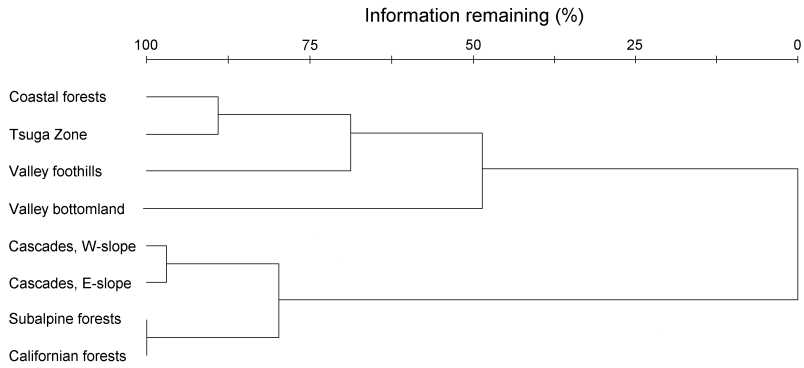

Fig. 17. Summary of floristic affinities between the eight forest zones.

species (11%) over hardwood twigs, eight species (9.8%) over conifer resin, and three species (3.7%) over rock or detritus. The frequencies of corticolous species varried between host species. *Pseudotsuga menziesii* and species of *Abies* (collectively) were rich in corticolous calicioids, with 38 and 32 species, respectively. Less diverse floras were associated with *Tsuga heterophylla* (24 species), *Thuja plicata* (22 species), and *Picea sitchensis* (13 species). Again, some of this variation was undoubtedly attributed to differences in sampling intensity (Table 2).

For most lignicolous calicioids, habitat characteristics and the physical quality of wood seemed to be more important than tree species. Some species, like *Chaenothecopsis savonica* and *Microcalicium ahlneri*, grew on well-decomposed conifer lignum and rotten bark in humid forests, usually in deep shade. Others, like *Calicium salicinum* and *Chaenothecopsis debilis*, mainly grew on hard lignum in semi-open deciduous forests. Worked wood was not available at most survey sites, but *Thelloma ocellatum*, *T. occidentalis*, and *Chaenotheca ferruginea* were repeatedly collected from old fence posts. Some predominately lignicolous calicioids, like *Calicium abietinum*, also grew on the bark of *Thuja plicata* and on other conifers with stringy bark.

Community composition

Calicioid communities differed among the main forest types. In the NMS ordination of forest types in calicioid species space, the two axes explained 88% of the community variation (Fig. 16). After rotation, 60% of this variation was explained by the second axis, aligned with the average elevation of collecting sites (axis 2). This axis was also related to the proportion of decorticated conifer wood among field specimens. The other axis (axis 1), representing 28% of the variation, was also related to differences in substrate availability, contrasting a high proportion of conifer bark (r = –0.87) with a high proportion of hardwood bark (r = 0.77) and lignum (r = 0.78). These interdependent variables are shown as vector overlays in Figure 16. Of the calicioid species, *Mycocalicium subtile* and *Chaenothecopsis nana* were most strongly associated with high elevation forests, while *Chaenotheca chlorella*, *Calicium salicinum*, and *C. adaequatum* were most strongly associated with hardwood substrates (Table 3). The dendrogram from cluster analysis gave a summary of floristic affinities between the eight forest zones (Fig. 17).

There were several ecological groups among the calicioid species. Resinicolous species, hardwood-twig species and lithophytic species were the most obvious examples of such groups. Affinities among some broadly distributed calicioids were revealed by a cluster analysis of the transposed community matrix. The species formed two major groups (Fig. 18). Species in the first group (A) preferred decorticated wood and/or hardwood bark. Most of them were most frequent at low elevations and had specific substrate requirements. Subdivisions within the group corresponded with subtle differences in distribution and/or substrate preferences. Most species in the second main group (B) were frequent in semi-open montane forests and exhib-

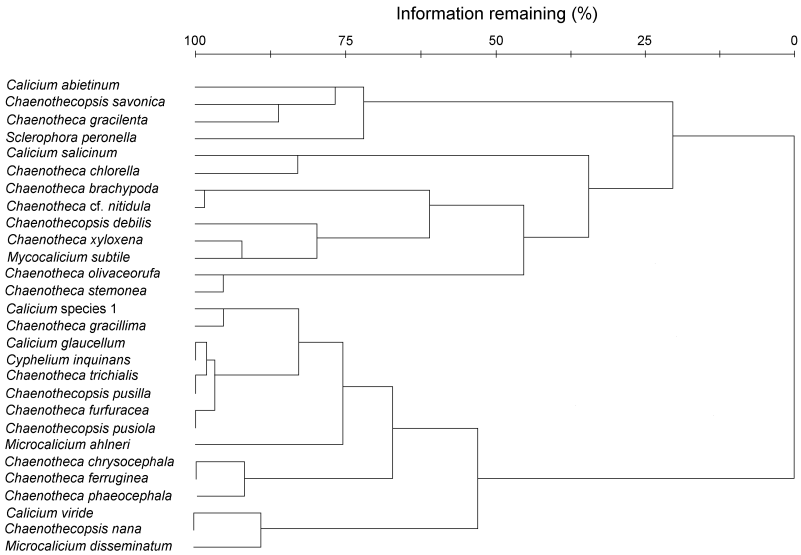

Fig. 18. Ecological affinities between some broadly distributed calicioid species.

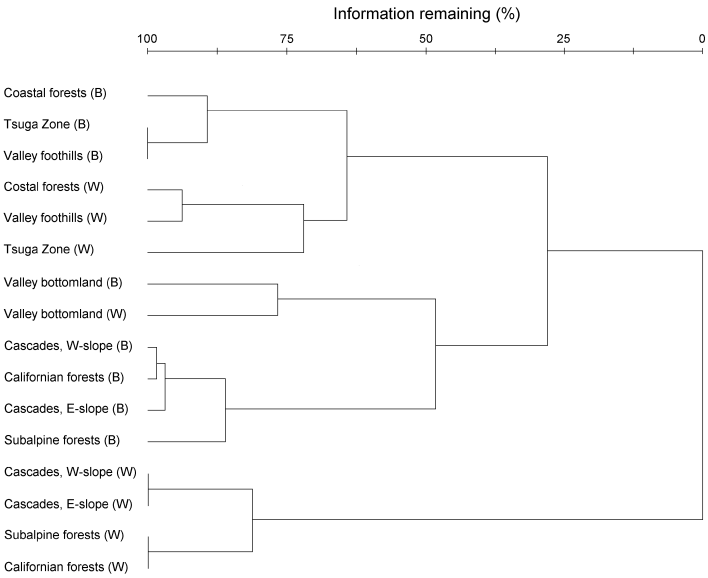

Fig. 19. Floristic affinities between field specimens of conifer bark (B) and wood (W) from the eight forests zones.

ited relatively low substrate selectivity. The group was divided into subgroups, two of which included common corticolous species from mid elevations in the Cascades and from the foothills of the Willamette Valley, respectively. The remaining taxa grew on conifer lignum and/or bark in humid montane forests (Fig. 18).

Calicioid community composition in specimens of conifer bark differed from those of conifer wood and these differences became more pronounced with increasing elevation. The dendrogram from cluster analysis provided a simple summary of floristic affinities between conifer bark and wood from the eight forests zones (Fig. 19). The species assemblages of conifer trunks in humid, low-elevation forests grouped together, with a clear distinction between bark and wood. Conifer bark communities in all montane forests were quite similar and resembled the communities on conifer bark and wood in open bottomland forests. Calicioid communities of decorticated conifer trunks in montane forests formed a group of their own, with both types of mid-elevation forests in the Cascades being slightly different from the subalpine forests and Californian forests, respectively (Fig. 19).

Discussion

The field surveys demonstrated that calicioid lichens and fungi are a diverse component in the mycoflora of western North America. A total of 82 species were identified, including several previously unknown species (Peterson & Rikkinen 1998, Rikkinen 1999, 2003a, 2003b). The collections also led to many range extensions, most of which have been discussed in two research notes, listing 27 species as new to North America, California, Oregon, or Washington (Rikkinen 1998, Peterson & Rikkinen 1999). *Calicium corynellum* and *Phaeocalicium matthewsianum* are here reported as new to Oregon and *Chaenotheca* cf. *nitidula* is reported as new to California, Oregon, and Washington. Also specimens corresponding to *Mycocalicium victoriae* and four taxonomically uncertain *Chaenothecopsis* species (cf. *aeruginosa*, cf. *amurensis*, cf. *nigra*, and cf. *vainioana*) are listed. Judging from these findings, and the rate at which new calicioids have been reported during the past few years (Goward 1999, Selva & Tibell 1999, Peterson 2000a), it is likely that many additional species still await discovery in the region.

Biogeographical patterns

The calicioid flora of the the study area includes several biogeographic elements. Most species have wide circumpolar, antitropical or azonal distributions, but there are also several endemics, like *Chaenothecopsis sitchensis*, *Mycocalicium sequoiae*, and *Stenocybe clavata* (Bonar 1971, Tibell 1991a, 1994, Rikkinen 1999). Most of the local endemics grow on coniferous substrates, this corresponding with a similar situation among endemic macrolichens (Goward & Ahti 1992). Most resinicolous endemics are restricted to one or two tree species that are also endemic to western North America. In addition to the corticolous and resinicolous species, the endemics are also known to include some terricolous and saxicolous species (Tibell 1976, 1994, McCune & Rosentreter 1992). There may also be endemics among the lignicolous and hardwood-twig species, but more work is still needed to clarify their distributions.

The diversity of resinicolous calicioids in the Pacific Northwest is probably higher than in any comparable region of the world. Somewhat similar species diversities have only been found in some temperate forests of East Asia (Titov & Tibell 1993, Tibell & Titov 1995, Titov 2001, Rikkinen unpubl.). The high diversity of calicioids on conifer resin, and coniferous substrates in general, is obviously related to the composition and history of forests in western North America. In most other temperate regions of the northern hemisphere deciduous hardwood forests or mixed hardwood-coniferous forests dominate. In the oceanic climate of the Pacific Northwest conifers dominate and hardwoods are only important in stressful or disturbed habitats, like in the lowlands of the Willamette Valley, riparian stands, and in avalanche tracks. Many of the local conifers are endemic and in all genera the largest and often longest lived species are found in this particular region (Franklin & Dyrness 1988).

Western North America and East Asia have acted as centers of survival for plant groups that previously had a more continuous range across the Holarctic, but suffered major constrictions in range as a consequence of climatic deterioration during the Pleistocene. Also the modern distributions of many lichens and fungi, including some resinicolous calicioids, may be strongly relictual. For example, *Mycocalicium sequoiae* only grows on exudates that issue from living trunks of *Sequoiadendron giganteum* and *Sequoia sempervirens* (Fig. 20). This relationship is likely to date back to the Mesozoic when both host genera were more widely distributed than today. Moreover, European amber fossils have shown that the current distribution of resinicolous *Chaenothecopsis* species with two-celled spores is a relict of an ancient Laurasian range (Rikkinen & Poinar 2000, Rikkinen unpubl.). Most extant species are only known from western North America or East Asia, and at least *C. asperopoda* occurs in both regions. *Chaenothecopsis golubkovae* is widely distributed in East Asia and has also been collected from the relict tertiary forests of Central Asia (Titov & Tibell 1993, Tibell & Titov 1995, Titov 1998, 2001). *Chaenothecopsis edbergii* has been found from the Pacific Northwest and from New Hampshire (Selva & Tibell

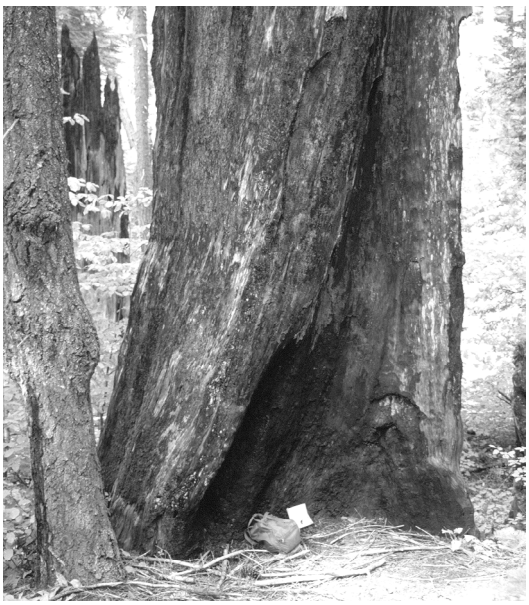

Fig. 20. Massive fire scar on basal trunk of *Sequoiadendron giganteum*. The scar supported a large colony of *Mycocalicium sequoiae* (South Grove Natural Preserve, CA, survey site G5).

1999). *Chaenothecopsis montana,* a resinicolous species with 1-celled spores, is common in western North America, but also occurs in northern Europe (Rikkinen 2003b).

Two species of calicioid lichens were recently found from European amber (Rikkinen 2003c). These fossils demonstrate that the morphologies and substrate ecologies of *Calicium* and *Chaenotheca* have remained similar for at least 40 million years. As there is no reason to believe that the fossilizations would have been immediately preceded by short periods of more rapid evolution, the initial divergences among these lichens must have happened in the very distant past. Also other fossils have shown that many modern epiphytic lichen genera, and possibly even species, were already present in the Tertiary (Poinar & Poinar 1999, Peterson 2000b, Poinar *et al*. 2000). For example, fossilized specimens of *Anzia* sect. *Anzia* have been found from Baltic amber (Rikkinen & Poinar 2002). Modern species of these epiphytes have a disjunct range involving East Asia and eastern North America. This distribution, together with the European fossils, indicates that the lichens once had a circum-Laurasian range. Printzen and Lumbsch (2000) used vegetation history and palaeoclimatic data to calibrate a molecular clock based on fungal ITS sequences from some epiphytic crustose lichens. Their results indicated that diversification within *Biatora* started already in the Late Cretaceous and took place during periods of climate cooling, when many new forest vegetation types evolved and spread in the Northern Hemisphere.

The endemic calicioids of the Pacific Northwest are not randomly distributed. As with the corticolous macrolichens (Goward & Ahti 1992), most endemic taxa have a temperate, essentially coastal distribution. The Cascade Mountains provide an important biogeographic boundary, dividing the ranges of coastal species from those of inland taxa (McCune 1984, Schofield 1984, Redhead 1989, Hammer 1995, Goward & Ahti 1992, 1997, McCune *et al*. 1997). Most of the coastal species probably survived Pleistocene glaciations at the immediate coast, while many inland species have recently migrated into the region from other areas that escaped glaciation. Among the endemic calicioids, *Chaenothecopsis sitchensis* is most restricted to the immediate coast (Rikkinen 1999). A majority of all collections are from large resin flows in root crevices of huge, old-growth *Picea sitchensis*. Sitka spruce is endemic to a narrow coastal zone extending from Alaska into northern California. The zone is usually only a few kilometers wide, and mostly confined to areas below elevations of 150 meters.

Habitat relationships

None of the 82 calicioid species were uniformly distributed throughout all types of forests within the study area. Some corticolous and lignicolous species were found at essentially all elevations, but even their frequencies varied between different forest zones. Calicioid diversity was generally promoted by heterogeneity in forest structure, especially by increasing availability of aged trees and snags but also hardwood twigs, preferably representing many different tree species. Exceptionally high species diversities were found from edge-habitats, like from mixed forest

stands bordering meadows, swamps or beaver ponds (Fig. 21).

Mean site level calicioid richness was highest in the foothills of the Willamette Valley. In other forest zones site level species richness generally decreased at both ends of the elevational gradient. The redwood forests of northern California were surprisingly poor in calicioid species (mean site level species richness 5.5). Also subalpine forests, especially in dry or semi-arid regions, provided a poor environment for most calicioids. However, some species, like *Chaenothecopsis* sp.1 and *Tholurna dissimilis* were restricted to exposed sites at high elevations. Many species that were frequent in the montane forests on western slopes of the Cascades, were rare in subalpine forests but reappeared at mid elevations east of the Cascade Crest.

Species diversities in the driest forests were generally low and many open woodlands east of the Sierra–Cascade Crest were totally devoid of calicioids. For example, they were searched for in vain from several sites in the *Pinus ponderosa* forests and *Juniperus occidentalis* woodlands of western Oregon and in the *Pinus monophylla-Juniperus osteosperma* woodlands of central California. Two weeks of collecting in the Sierra Nevada resulted in less than 100 specimens, due to an emphasis on dry, high elevation forests. Mixed conifer forests at mid elevations on the western slopes of the Sierra Nevada seemed to be rich in calicioid species, but these forests were sampled too sparsely to permit real comparisons with the Oregonian forest types.

The relationship between calicioids and old forest structure is well established (Tibell 1992, Selva 1994, Holien 1996, Kuusinen & Siitonen 1998, Peterson 2000a). Old forest features enhance calicioid diversity is several ways. Aged forests tend to provide a wide variety of suitable substrates and microenvironments that combine favorable illumination conditions with high atmospheric humidity. At the short term, most calicioid species are likely to suffer from major disturbances, like extensive forest fires. However, they clearly benefit from a legacy of small and medium scale disturbances, such as those caused by storms, slope processes, insect outbreaks and beaver activity. On the whole, differences in disturbance histories can be important in explaining many present day variations in calicioid diversity (Rikkinen 1995, 2003b).

Fig. 21. High calicioid species diversities were often recorded from edge-habitats, like from old fragmented forests bordering alpine meadows (Iron Mountain, OR, survey site D3).

Several calicioid species were relatively frequent in semi-open forests at low elevations, but more or less absent from low-elevation rainforests and from montane forests. *Chaenotheca hispidula* was only collected from the Willamette Valley, where it grew together with *Chaenotheca olivaceorufa*, *Chaenothecopsis rubescens*, *C.* cf. *vainioana*, and the two *Sclerophora* species. All these calicioids associate with *Trentepohlia*. This group of algae seems to be relatively sensitive to low temperatures and thus minimum temperatures may be important in limiting the associated calicioids to relatively low elevations and/or protected sites (Rikkinen 1995, 1998, Skarp 1999). The forests of the Willamette Valley are at the low end of the elevational gradient but being in the rain shadow of the Coast Range they are not nearly as wet as low-elevation rainforests. Also many forests in the Klamath region are quite xerophytic, partly due to the rain shadow of the

Fig. 22. Deciduous forests and mixed deciduous-coniferous forests of the Willamette Valley house several locally rare calicioid species (William L. Finley National Wildlife Refuge, OR, survey site C8).

Siskiyou Range but also because of open canopies on serpentine soils. These forests supported rich calicioid floras, with a distinct combination of low-elevation taxa and species that generally had their greatest frequency in more continental portions of the study area. *C. olivaceorufa* was frequent in coastal forests and in the Willamette Valley, but rare in the intervening *Tsuga heterophylla* Zone (Rikkinen 1998).

Several calicioid species in the deciduous woodlands and mixed hardwood-coniferous forests of the Willamette Valley seemed to be locally rare and possibly threatened. Even in favorable environments they were found from a limited number of microhabitats and in some sites all species grew on a single remnant snag. This type of distribution could reflect their ability to effectively exploit a fragmented environment. Many lignicolous and corticolous calicioids are probably effectively dispersed by woodpeckers and thus able to reach most suitable snags within a relatively large area. On the other hand, the slow turnover of large hardwood snags might seriously jeopardize the future success of these species. Also Lõmus and Lõmus (2001) paid attention to the special conservational value of large hardwood snags for lignicolous lichens. Undoubtedly the present distribution of calicioid lichens like *Chaenotheca hispidula* and *Sclerophora* cf. *farinacea* is a remnant from times when most woodlands in the Willamette Valley had not yet been converted to agricultural and suburban land uses (Fig. 22). In addition to housing locally rare calicioids, the remaining forests and woodlands provide an important habitat for rare and endangered macrolichens (Peterson *et al*. 1998).

Calicium lenticulare and some other species were restricted to humid low-elevation forests. As already mentioned, many of the local endemics had this type of distribution. The coastal species were usually not found further east than in mid-elevation forests on the west slopes the Cascades. It is quite possible that some of them reappear in the inland extension of Pacific maritime influence in the northern Rocky Mountains (McCune 1984). Conversely, many frequent and widely distributed corticolous calicioids, like *Calicium viride* and *Chaenothecopsis nana*, preferred seasonally dry forests and distinctly avoided low-elevation rainforests. Also many lignicolous species, like *Chaenothecopsis debilis* and *Mycocalicium subtile*, were practically absent from rainforest snags. These species preferred hard lignum and became confined to very exposed microhabitats with decreasing elevation. Some of them, like *Calicium glaucellum* and *M. subtile*, reappeared on wind-blown sites at the immediate coast, while others, like *Cyphelium pinicola*, were restricted to interior valleys at the lower limits of their range.

The lack of many calicioid species from coastal rainforests was conspicuous given that within less oceanic regions they often associate with old-growth stands. The primary reason for the phenomenon is not known, and probably in fact is a combination of several factors. Rainforest lichens must cope with high overall moisture and infrequent drying. Prolonged hydration, in turn, may be directly damaging to most lichenized calicioids. Many species seem to require a high atmospheric humidity but avoid liquid water. The critical period in costal rainforests is probably winter, when even well-protected microhabitats remain wet for extended periods. Tibell (1980) noted that the scarcity of lignicolous calicioids may reflect more the lack of suitable substrate than adverse climatological conditions. The species that prefer hard lignum

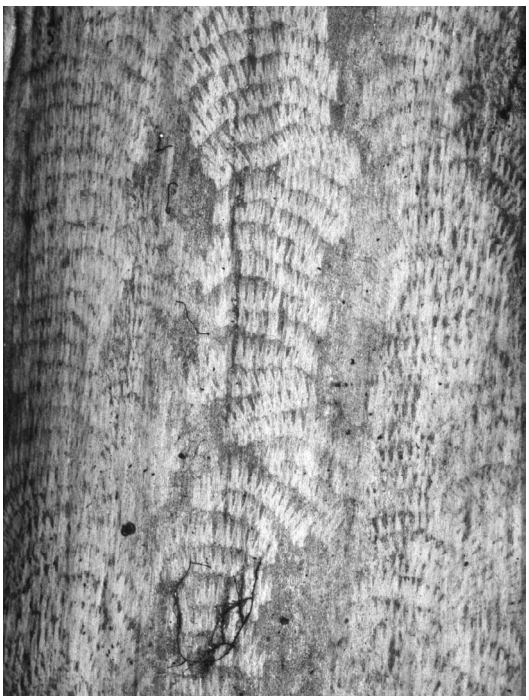

Fig. 23. Large mollusks (*Ariolimax columbianus*) can be detrimental to lignicolous calicioids in humid low-elevation forests. Slug feeding marks on hard decorticated wood of *Taxus brevifolia* (Little Sinks Research Natural Area, OR, survey site C1).

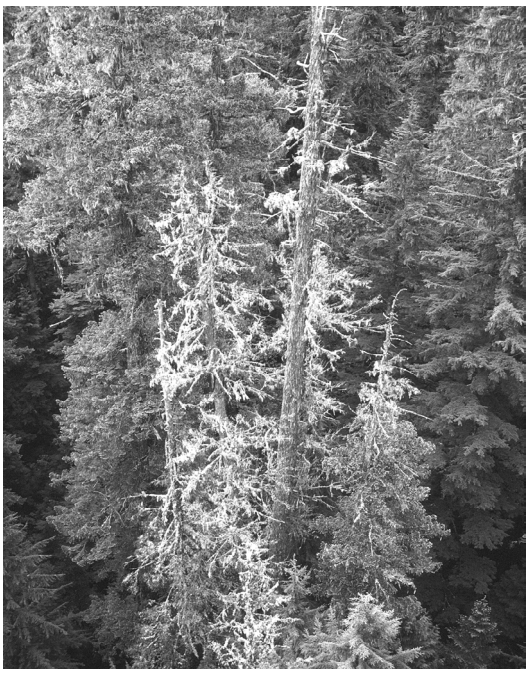

Fig. 24. Dead treetops in the upper canopy may provide ideal habitats for some calicioids (Wind River Canopy Crane Research Facility, WA, survey site B2).

are indeed short of suitable substrate in the lower strata of temperate rainforests, where dead tree trunks decompose relatively rapidly. The decay of wood also leads to a soft lignum structure not appreciated by many species. Moreover, most lignum surfaces tend to become covered by atmophytic algae, leafy liverworts and mosses. Middelborg and Mattsson (1987) suggested that bryophyte competition may explain the lack of some calicioid species from the euoceanic west coast of Norway. In the Pacific Northwest, banana slugs (*Ariolimax columbianus*) frequently use trunk-base hollows and other calicioid microhabitats as their day-time hideouts. These large mollusks eat plant material and fungi, but also graze on lichens and lignicolous algae. Undoubtedly this grazing can be detrimental to lignicolous calicioids (Fig. 23).

While the high humidity characteristics of low-elevation rainforests seemed to exclude many calicioid species form snags and lower tree trunks, some of the species are probably common in the upper canopy, where dead treetops provide a more suitable environment. Unfortunately the treetops are extremely inaccessible and very little is still known about their lichen flora (Fig. 24). McCune *et al*. (2000) found that within one old-growth forest in the *Tsuga heterophylla* Zone more species of lichens showed an association with dead tree tops than any other single epiphytic habitat in the forest. One reason may be that dead treetops are often used as bird perches.

The macroclimatic optima of many circumpolar calicioids are in relatively continental regions (Tibell 1975, 1980, Middelborg & Mattson 1987, Rikkinen 1995, Holien 1996). As to their light requirements, the species range from sciophilous to photophytic, with many species being distinctly anheliophytic, i.e., preferring situations without much direct sunlight, but with plenty of diffuse light. A number of species thrive in open shade situations which combine adequate light levels with relatively cool temperatures and a high atmospheric humidity. Such conditions are often experienced on north-facing tree trunks,

Fig. 25. A phototropism guides the growth of *Chaenothecopsis sitchensis* ascomata in deep bark crevices.

especially in forests bordering forest glades. The effect is most pronounced in high mountains of continental regions and rarely develops in hyperoceanic areas with cloudy and foggy climates. During the winter open shade conditions occur in many habitats that would be classified as sciophilic during the summer. The snow cover has dramatic effects on the illumination conditions of montane forests. Many calicioid microhabitats are likely to experience their highest photon flux densities during the winter and early spring and have thus been termed cheimophotophytic (Rikkinen 1995).

In the mountains of the Pacific Northwest there was a clear relationship between zonal distributions and the frequency of calicioid species with yellow or green pulvinic acid derivatives in a well-developed cortex. *Calicium viride*, *Chaenotheca chrysocephala* and *Cyphelium pinicola* were often abundant on the basal trunks of trees and snags in semi-open montane forests, and also grew on the undersides of slanting trunks and branches. In such habitats light intensities may be comparatively low in summer, but relatively high in winter due to light reflected from the snow. Especially during clear days in early spring lichens in such habitats can receive abundant light, this being enriched in blue and UV wavelengths. This probably explains the common occurrence of pulvinic acid derivatives and other photoprotective pigments in the cortices of cheimophotophytic calicioid species. *Letharia vulpina* and *L. columbiana* are well known examples of bright yellow macrolichens. Also these epiphytes live in high UV environments and accumulate large amounts of pulvinic acid derivatives in their thalli (Rikkinen 1995).

Light is not as important for non-lichenized calicioids, like *Chaenothecopsis sitchensis*, which often grows under slabs of dead bark in almost complete darkness. However, even this species is not insensitive to light. Its ascomata have longer stalks than those of any other species of the Mycocaliciaceae and a phototropism seems to involved in guiding their growth through cracks and crevices (Fig. 25). Similar phenomena can often be seen among *Chaenotheca furfuracea, C. gracilenta*, *C. gracillima* and other sciophilic calicioids. Also these lichens have long stalks and they frequently occur in habitats with very low light intensities (Koskinen 1955, Barkman 1958).

Most shade-tolerant calicioid lichens, like *Chaenotheca brachypoda*, *C. chlorella,* and *C. furfuracea*, are distinctly aerohydrophytic. They had comparatively wide substrate tolerances in humid low-elevation forests, but became more and more restricted to trunk-base hollows at higher elevations and in dry forests. Even in relatively dry forests the basal hollows of large snags often supported species-rich 'azonal' communities of aerohydrophytic calicioids. The microclimates of such hollows are probably quite similar under most macroclimatic conditions. The environment remains particularly stable if soft lignum can store enough water to compensate for the summer drought. Also the thickness and duration of the winter snow cover can be quite important here. In any case, there was a strong correlation between macroclimate and the minimum size of snags that could support aerohydrophytic calicioids. While even relatively small stumps had such communities in the Willamette Valley and in the *Abies amabilis*

Zone, relatively huge snags were required on the eastern flanks of the Cascade Range and in mid elevation forests of the Sierra Nevada. Conversely, even the largest snags in the *Juniperus occidentalis* Zone and in the subalpine forests of the White Mountains were devoid of aerohydrophytic calicioid lichens.

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